BACHELOR THESIS & COLLOQUIUM – ME184841

DEVELOPMENT OF MARINE LOADING AND UNLOADING SYSTEM FOR RO-RO VESSEL

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DOUBLE DEGREE PROGRAM
DEPARTEMENT OF MARINE ENGINEERING
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TUGAS AKHIR – ME184841

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JURUSAN TEKNIK SISTEM PERKAPALAN
FAKULTAS TEKNOLOGI KELAUTAN
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SURABAYA
2019

APPROVAL FORM

DEVELOPMENT OF MARINE LOADING AND UNLOADING SYSTEM FOR RO-RO VESSEL

BACHELOR THESIS

Submitted as one of Requirements to obtain Bachelor Degree in Engineering
on
Marine Manufacturing and Design (MMD)
Bachelor Program in Marine Engineering Department
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember

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DECLARATION OF HONOR

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Department	:	Marine Engineering

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Surabaya, July 2019

Arie Nanda Rizaldi

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Development Of Marine Loading And Unloading System For Ro-Ro Vessel

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ABSTRACT

Ship stability is one of important criteria for ship safety as required by IMO and Indonesia Classification Bureau (BKI) in various rules. One of the rules is the IMO code of Intact Stability. Among many factors affecting the ship stability is the ship load which in the application varies in weight and types of vehicles. In its use, Maxsurf has been used to analyze various conditions of the ship, including stability. However, Maxsurf is too complicated to be used by ordinary people, and training is needed to run the program. For that a package is needed to mediates laymen and Maxsurf for easy analysis. The current research developed a loading and unloading system to analyse the ship stability in such variation of conditions using a 500 GT ferry as the target ship. The system was established in the form of Excel package connected to Maxsurf Stability for a user friendlier application. Visual Basic was employed to write the codes (coding) for the package command. Simulation output revealed that at initial condition of zero loading, the ship has a maximum GZ of 1.4 m at heel angle of about 40^o. Afterwards, the ship slowly loses its righting moment and started to capsize at about 75^o heel angle. At half loaded, third-quarterly loaded and a fully loaded, the ship possesses maximum GZ of 1.1 m, 1.05 m and 0.97 m respectively at similar heel angle of about 30^o. Correspondingly, the ship started to capsize after heeling for about 76^o, 74^o and 73^o respectively. At overload condition, the ship possesses a maximum GZ of 0.92 m at heel angle of about 300 and started to capsize at about 71^o heel angle. At all conditions includes overloaded, the ship displays positive GZ values and is safe to sail as evidenced by its compliance to IMO Intact Stability rule. The research has successfully developed the loading and unloading system capable of analysing the ship stability at various loading conditions.
Keywords: Ship stability; Maxsurf; VBA macro; Ship loading unloading; Ro-ro vessel

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Development Of Marine Loading And Unloading System For Ro-Ro Vessel

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ABSTRAK

Stabilitas kapal adalah salah satu kriteria penting untuk keselamatan kapal seperti yang disyaratkan oleh IMO dan Biro Klasifikasi Indonesia (BKI) dalam berbagai aturan. Salah satu aturannya adalah kode IMO Intact Stability. Di antara banyak faktor yang mempengaruhi stabilitas kapal adalah muatan kapal yang dalam aplikasi bervariasi dalam berat dan jenis kendaraan. Penelitian saat ini mengembangkan sistem bongkar muat untuk menganalisis stabilitas kapal dalam variasi kondisi menggunakan feri 500 GT sebagai kapal target. Sistem ini dibuat dalam bentuk paket Excel yang terhubung ke Maxsurf Stability untuk penggunaan yang lebih mudah untuk pengguna. Visual Basic digunakan untuk menulis kode (coding) untuk perintah pada aplikasi. Hasil simulasi mengungkapkan bahwa pada kondisi awal tanpa muatan, kapal memiliki GZ maksimum 1,4 m pada sudut kemiringan sekitar 40^o. Setelah itu, kapal perlahan kehilangan momen penguatnya dan mulai terbalik pada sekitar 75^o sudut kemiringan. Pada muatan setengah, muatan tiga per empat, dan muatan penuh, kapal memiliki GZ maksimum masing-masing 1,1 m, 1,05 m dan 0,97 m pada sudut tumit yang sama sekitar 30^o. Sesuai dengan itu, kapal mulai terbalik setelah mengalami heeling sekitar 76^o, 74^o dan 73^o masing-masing. Pada kondisi kelebihan beban, kapal memiliki GZ maksimum 0,92 m pada sudut tumit sekitar 30^o dan mulai terbalik pada sekitar 71^o sudut kemiringan. Pada semua kondisi termasuk kelebihan muatan, kapal menampilkan nilai GZ positif dan aman untuk berlayar sebagaimana dibuktikan dengan kecocokannya dengan aturan IMO Intact Stability. Penelitian ini telah berhasil mengembangkan sistem bongkar muat yang mampu menganalisis stabilitas kapal di berbagai kondisi pemuatan.

Keywords: Stabilitas kapal; Maxsurf; VBA macro; Loading unloading kapal; Kapal ro-ro

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PREFACE

Alhamdulillahirobbil 'alamin, all praises is to the almighty Allah SWT for the gracious mercy and tremendous blessing that enables me to accomplish this bachelor thesis entitled: Development of Marine Loading and Unloading System for Ro-Ro Vessel. This bachelor thesis is presented to fulfill one of the requirements in accomplishing S-1 Degree in Marie Engineering, Double Degree program, Institut Teknologi Sepuluh Nopember Surabaya.

I would like to express my special appreciation to my supervisor, Ir. Amiadji, M.Sc. and Sunarsih, S.T., M.Eng., Ph.D. for their valuable assistance and inspiration to the completion of this bachelor thesis. I also would like to express my deep gratitude to my inspiring examiner, who has given me valuable input for the improvement of this bachelor thesis.

I also would like to express my gratitude to Dr. Eng Muhammad Badrus Zaman, ST., MT. as head of the Department of Marine Engineering, who has given his best occupation to the Department of Marine Engineering so developing a good quality education for his students.

I also would like to extent my gratitude to Taufik Fajar Nugroho, ST., M.Sc. as my advisor lecturer, for the guidance during my study in university and patiently show me how to passing through all problem that I had when doing my study in university.

Furthermore, I would like to say thanks to Achmad Baidowi ST., MT. who has giving the inspiration to doing this research, and giving me some advice and motivation during my time of research. So that my research would be better.

The greatest honor and appreciation would be dedicated to my beloved parents, his father Syafarizal and my mother Musripatun. It is truly undoubted that loves, cares, spirits, motivation, patience and willingness to wait for my graduation and timeless prayers during days and nights are everything for me. My sincere thanks and love are also dedicated to my beloved sisters, Ria Dinda Syafitri and Risfadilla Andra Junior, and my brother Akbar Nanda Rizaldi, thank you so much from my deepest heart to you all.

I also would like to give my gratitude to member and staff of Marine Manufacturing and Design for introduce me to Engineering Design field of study. Also, for giving me knowledge, motivation, and companion during my time in laboratory and during my research. Without them, I might be cannot finish my research.

I also would address my appreciation to my beloved big family of Marine Engineering 2015 "Salvage '15", especially for member of *kontrana racun tikus*: Affifudein Zuhri, Atfal Affandi, Zeka Angger H., Ryanmizar Satrio, Habib

Muhammad, Febrian Rohim, Faisal Queba, Ardi Pangestu, Luqman, Anas Ardiansyah. Also, to close friend Sultan Brillianto Ardhoury, Dhanang Aji Purnomo, Herdira Dita Ramadhani, Muhhamad Irsyad Saihilmi, Akbhar Buddy Al-Afgan. Last but not least member of *tikus family*: Hadi Mulki, Azzahra Nirwana, Nabilla, Deliar Candra, thank you so much for being such a great companion during our togetherness at campus.

I also would like to give my gratitude to learning institution UNO Education and Mr. Krisna for introduce and teaching things that support me for doing the research. Without it this research would not be completed.

Surabaya 2019

Arie Nanda Rizaldi

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CHAPTER I

INTRODUCTION

1.1. Background

Stability is an important parameter in the safety of ships as required by the International Maritime Organization (IMO) and the Indonesian Classification Bureau (BKI). The stability of a ship refers to the ability of the ship to maintain its position on water. The failure of the ship to maintain stability can result in the ship experiencing various problems such as accidents, sinking, damage, etc. For this reason, it is important to pay attention to the stability of any type of ship sailing.

The stability criteria recently used to evaluate stability of ships in Indonesia was adopted from the intact stability criteria of IMO which is used also for ocean going ships. This stability criteria was developed statistically in 1936 based on safely operating and ships capsized with different ships type. The geometry characteristics of the sample ships may different with the ro-ro ferries of Indonesia especially for ships built in Indonesia. This can be seen from the difference of geometry characteristics of ro-ro ferries built in Indonesia and built in foreign country (Asri, Thaha, Pallu, & Misliah, 2014).

The same thing applies to the ro-ro ferry services that operate in Indonesia. Ferries are important in Indonesian transportation because of the large number of islands which make up the nation. Statistics provided by the. Directorate of Land Transportation, Ministry of Transportation show that there are 33 million passengers, 14 million tons of general cargo, and 9.8 million vehicles carried annually by ferries in Indonesia (Anggoro, 2008). Ferries that carry many passengers and vehicles must pay attention to stability, because it concerns the safety of passengers on board. For that passenger capacity must be limited, as well as vehicles loading, so that the ship remains stable when sailing. These restrictions have been planned, both passengers and vehicles during the design process of the ship.

The plan also includes arranging vehicles when on board. Poor arrangement resulted in the weight not being distributed evenly to the ship resulting in the ship becoming unbalanced. This imbalance causes the stability of the ship to be disrupted, which in turn will cause problems as mentioned above. For this reason, planning in the arrangement of the vehicles on the ship is made, so that the weight distribution is evenly distributed throughout the ship.

But the real situation is more dynamic than planned. Vehicles that enter the ship are not always as planned because the condition of the port and vehicles entering the ship also vary, Because of the variety of traffic that arrives for each sailing, there has to be some flexibility and 100% consistency is not a practical objective (Hodgkins, 2015). Another thing that is also influential is the arrangement of vehicles on the ship because even though the vehicle that will enter has been weighed but the wrong arrangement of the ship will result in the ship losing its balance.

Another problem is that sometimes the crew is not aware that the condition is because it looks fine at the beginning, but when exposed to other factors such as the movement of ships, waves and wind the ship will tilt and sink. As happened in the ship KMP. Rafeila 2 (Komite Nasional Keselamatan Transportasi, 2016). Therefore, a software that is quite practical and fast is needed to be used to determine the stability of the ship.

In its use, Maxsurf has been used to analyze various conditions of the ship, including stability. However, Maxsurf is too complicated to be used by ordinary people, and training is needed to run the program. For that we need a package that mediates laymen and Maxsurf for easy analysis.

Microsoft Excel is an alternative solution to the problems mentioned. Because it is user friendly and does not need to make software that must be installed again on the device. What needs to be done is to write the command on Visual Basic that is in Microsoft Excel itself or called Visual Basic for Application (VBA). This method has actually been made for various simple automation systems, such as in research from Wong (2010), which uses in the field of chemical engineering. However, no one has made the package to help analyze the stability of the ship.

In this research the writer will analyze the effect of vehicle load with the stability of the ship, when the vehicle enters the ship with dynamics that is different from the plan for loading the ship at the time of planning. This simulation was carried out using the Maxsurf application which was integrated with Microsoft Excel, and the ship that analyzed was the ferry ro-ro.

1.2. Problem Statements

Good vehicle planning in ferry ro-ro is needed so that the load weight can be distributed evenly to the ship. Therefore, an analysis is needed that can determine the effect of the arrangement of the vehicle with the stability of the ship. Therefore, that in this analysis research has the formulation of the problem as follows:

1. How to connect Maxsurf with Microsoft Excel to develop loading software?
2. How is the process of analyzing the stability of the ro-ro ferry on Maxsurf with input variations of various types of vehicles with so many variations?

1.3. Research Objectives

To answer all the questions contained in the problem statement above, this study has the following objectives:

1. To conduct stability analysis on the ro-ro ferry on Maxsurf with input variations of various vehicles with weight variations
2. To connect Maxsurf with Microsoft Excel to develop loading software

1.4. Research Limitation

To be able to carry out this research, the limitation of the problem that needed is as follows:

1. The ship used as input in this analysis is a ro-ro Ferry type, 500 GT type vessel
2. The scope of this study is stability when the ship loads the vehicle on the ship and arranges the vehicle inside the ship
3. The analysis of the stability is conducted using the connection between Maxsurf Stability and Microsoft Excel.

1.5. Significance of Research

The benefits that can be obtained from this thesis are:

1. As a learning about stability analysis on ro-ro ferry when loading vehicles with various variation conditions
2. Knowing the state of the cargo handling for each different vehicle.

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CHAPTER II

LITERATURE REVIEW

2.1. Ship Stability

The stability of a ship refers to the ship's ability to stay upright in the water. Various causes can affect the stability of a ship and cause the ship to turn upside down. However, these causes can be controlled. Unstable ships will cause various problems, such as accidents, damage, sinking and so on. For fishing crew, safety must be a top priority that must be considered, prevent damage to ships, prevent fatal accidents, and preserve the environment (oil spills, shipwrecks at sea).

According to Eric Tupper in his book Introduction to Naval Architecture (1996), it is said that the concept of stability can be explained by appreciating the body of the ship, which tends to be upright from an external force. Figure 2.1 below is the condition of the ship in position W_0L_0 then rotating to position W_1L_1..

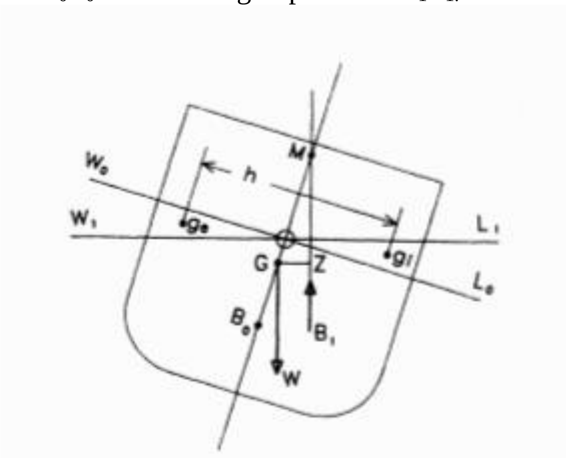


Figure 2. 1: Small Angle Stability (Tupper, 1996)

The inclination does not affect the position of G, the ship's centre of gravity, provided no weights are free to move. The inclination does, however, affect the underwater shape and the centre of buoyancy moves from B_0 to B_1. This is because a volume, v, represented by W_0OW_t, has come out of the water and an equal volume, represented by L_0OL_1, has been immersed

If g_e and g_i are the centroids of the emerged and immersed wedges and gegi = h, then:

$B_0B_1 = \frac{v \times h}{\nabla}$ ……………………………………………………………(2.1)

where ∇ is the total volume of the ship.

In general, a ship will trim slightly when it is inclined at constant displacement. For the present, this is ignored but it means that strictly B_0, B_1, ge etc., are the projections of the actual points on to a transverse plane.

The buoyancy acts upwards through El and intersects the original vertical at M. This point is termed the metacenter and for small Inclinations can be taken as fixed in position. The weight W = mg acting downwards and the buoyancy force, of equal magnitude, acting upwards are not in the same line but form a couple W x GZ, where GZ is the perpendicular on to B_1M drawn from G. As shown, this couple will restore the body to its original position and in this condition, the body is said to be in stable equilibrium. GZ = GM sin φ and is called the righting lever or lever and GM is called the metacentric height For a given position of G, as M can be taken as fixed for small inclinations, GM will be constant for any particular waterline. More importantly, since G can vary with die loading of die ship even for a given displacement, BM will be constant for a given waterline, In Figure 2.1 M is above G, giving positive stability, and GM is regarded as positive in this case.

If, when inclined, the new position of the center of buoyancy, B_1, is directly under G, the three points M, G and Z are coincident and there is no moment acting on the ship. When the disturbing force is removed, the ship will remain in the inclined position. The ship is said to be in neutral equilibrium and both GM and GZ are zero.

A third possibility is that, after inclination, the new center of buoyancy will lie nearer to the centerline than G. There is then a moment W X GZ which will take the ship further from the vertical. In this case, the ship is said to be unstable and it may heel to a considerable angle or even capsize. For unstable equilibrium, M is below G and both GM and GZ are considered negative.

The above considerations apply to what is called the initial stability of the ship, that is when the ship is upright or very nearly so. The criterion of initial stability is the metacentric height. The three conditions can be summarized as:

M above G	GM and GZ positive	stable
M at G	GM and GZ zero	neutral
M below G	GM and GZ negative	unstable

2.1.1. Initial Stability

A. B. Biran in his book Ship Hydrostatic and Stability (Biran, 2003) explains that the forces W and Δ are equal and linear and the ship is equilibrium condition. Let the ship heel to the starboard with an angle φ. Assume that the heel angle is small. As previously explained, we leave the ship as a waterline as inclined to port, with the same angle φ. This is done in Figure 2.2 (b) where the new waterline is WφLφ. If the weights are fixed, as they should be, the center of gravity remains the same position, G. Because a submerges volume at starboard, and equal volume emerges at port, the center of buoyancy moves to starboard, to a new position, Bφ. Both forces W and Δ are vertical, which is perpendicular to the waterline WφLφ. These forces form a moment that tends to return the ship towards the port, which is to initial condition. We say that the ship is stable.

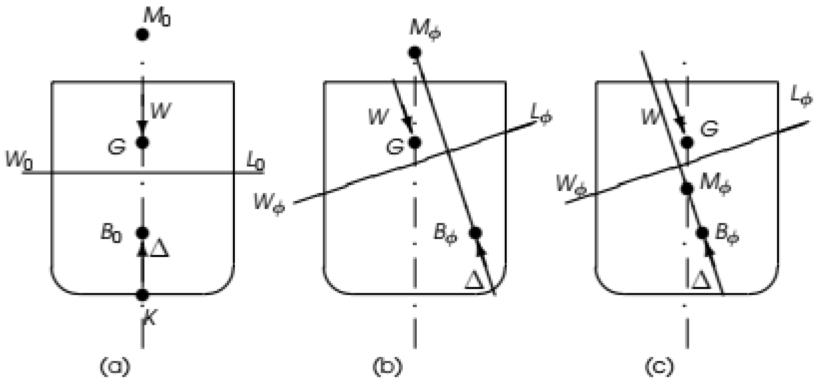


Figure 2. 2: Initial Stability (Biran, 2003)

Figure 2.2 (c) also shows the ship heeled towards starboard with an angle φ. In the situation shown in this figure the moment of the two forces W and Δ heels the ship further towards starboard. We say that the ship is unstable. The difference between the situations in Figures 2.2 (b) and (c) can be described elegantly by the concept of metacenter. For a ship, the dot-point line is the trace of the port-to-starboard symmetry plane, that is the centreline. More generally, for any floating body, the dot-point line is the line of action of the buoyancy force before heeling. The new line of action of the buoyancy force passes through the new centre of buoyancy and is perpendicular to WφLφ. The two lines intersect in the point Mφ. we called this point metacentre.

In figure 2.2, we choose a reference point, K, at the intersection of the centreline and the baseline and we measure vertical coordinates from it, upwards. Thus defined, K is the origin of z-coordinates. A good recommendation is to choose K as the lowest point of the ship keel; then, there will be no negative z-coordinates. We remember easily the chosen notation because K is the initial letter of the word keel.

In the same figure M0 is the initial metacentre, which is the metacentre corresponding to the upright condition. Dropping the subscripts 0 we can write

GM = KB + BM – KG……………………………………………………...(2.2)

and the condition of initial stability is expressed as

GM > 0…………………………………………………………………...(2.3)

The vector GM is called metacentric height. The vector KB is the z-coordinate of the centre of buoyancy; it is calculated as the z-coordinate of the centroid of the submerged hull as one of the results of hydrostatic calculations. The vector KG is the z-coordinate of the centre of gravity of the floating body; it results from weight calculations. The quantities KB and BM depend upon the ship geometry, the quantity KG upon the distribution of masses.

2.1.2. Intact Stability

Natural law acts independently of human will and they always regulate the phenomena they apply. Man-made laws, in terms of our stability rules, have other meanings. The stability rules stipulate criteria for approving ship designs, accepting new buildings, or allowing ships to sail out of the port. If certain vessels meet the regulatory requirements provided, that does not mean that the ship can survive all challenges, but its chances of survival are good because the stability rules are based on sufficient experience and a reasonable theoretical model. Conversely, if a particular ship does not meet certain regulations, it does not have to be reversed, only the risk is higher and the owner has the right to reject the design or the authorities have the right to prevent the ship from sailing out of the port. The stability rule, in fact, is a code of practice that provides a reasonable safety margin. This code is mandatory not only for designers and builders, but also for master ships that must check whether their vessels meet the requirements in the proposed loading conditions.

2.1.2.1. The IMO code on intact stability

The International Maritime Organization (IMO) is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. As a specialized agency of the United Nations, IMO is the global standard-setting authority for the safety, security and environmental performance of international shipping. Main role of them is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented. (International Maritime Organization (IMO), 2019). The intact stability criteria of the code apply to ‘ships and other marine vehicles of 24 m in length and above’. Countries that adopted these regulations enforce them by issuing corresponding national ordinances. In addition, the Council of the European Community published the Council Directive 98/18/EC on 17 March 1998. (Biran, 2003).

2.1.2.1. Passenger and cargo ships

The code uses frequently the terms angle of flooding, angle of down flooding; they refer to the smallest angle of heel at which an opening that cannot be closed weathertight submerges. Passenger and cargo ships covered by the code shall meet the following general criteria (International Maritime Organization, 2008):

1. The area under the righting-arm curve should not be less than 0.055 m rad up to 30◦, and not less than 0.09 m rad up to 40◦ or up to the angle of flooding if this angle is smaller than 40◦.
2. The area under the righting-arm curve between 30◦ and 40◦, or between 30◦ and the angle of flooding, if this angle is less than 40◦ should not be less than 0.03 m rad.
3. The maximum righting arm should occur at an angle of heel preferably exceeding 30◦, but not less than 25◦.
4. The initial metacentric height, GM_0, should not be less than 0.15 m.

Passenger ships should meet two further requirements. First, the angle of heel caused by the crowding of passengers to one side should not exceed 10◦. The mass of a passenger is assumed equal to 75 kg. The centre of gravity of a standing passenger is assumed to lie 1 m above the deck, while that of a seated passenger is taken as 0.30 m above the seat. The second additional requirement for passenger ships refers to the angle of heel caused by the centrifugal force developed in turning. The heeling moment due to that force is calculated with the formula.

$$MT = 0.02 \frac{V_0 2}{L_{WL}} \Delta \left(KG - \frac{T_m}{2} \right) \qquad (2.4)$$

Where V0 is the service speed in ms^{-1}. Again, the resulting angle shall not exceed 10◦. The reason for limiting the angle of heel is that at larger values passengers may panic. The application of this criterion is exemplified in Figure 2.3.

In addition to the general criteria described above, ships covered by the code should meet a weather criterion that considers the effect of a beam wind applied when the vessel is heeled windwards. We explain this criterion with the help of Figure 2.3.

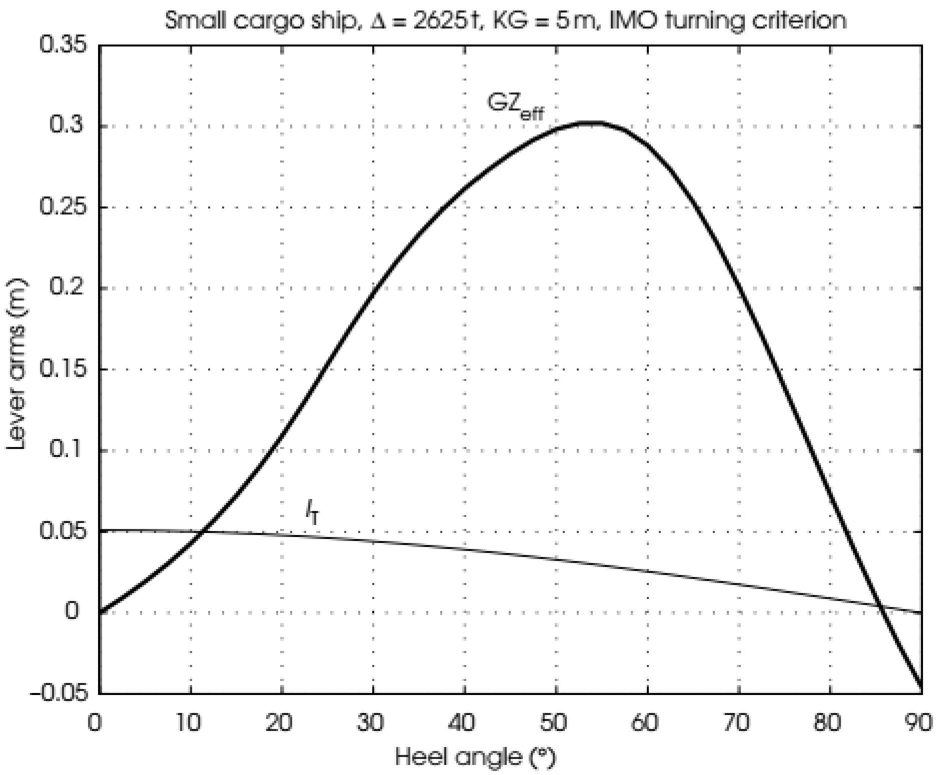


Figure 2. 3: The IMO weather criterion (Biran, 2003)

The code assumes that the ship is subjected to a constant wind heeling arm calculated as:

$$\ell_{w1} = \frac{P\,AZ}{1000g\Delta} \qquad (2.5)$$

where P = 504 N m^{-2}, A is the projected lateral area of the ship and deck cargo above the waterline, in m^2, Z is the vertical distance from the centroid of A to the centre of the underwater lateral area, or approximately to half draught, in m, Δ is the displacement mass, in t, and g = 9.81 m s^{-2}. Unlike the model developed used by the US Navy, IMO accepts the more severe assumption that the wind heeling arm does not decrease as the heel angle increases. The code uses the notation θ for heel angles; we shall follow our convention and write φ. The static angle caused by the wind arm l_{w1} is φ_0. Further, the code assumes that a wind gust appears while the ship is heeled to an angle φ_1 windward from the static angle, φ_0. The angle of roll is given by

$$\phi 1 = 109k\, X_1\, X_2 \sqrt{rs} \qquad (2.6)$$

where φ_1 is measured in degrees, X_1 is a factor given in Table 2.4 of the code, X_2 is a factor given in Table 2.5 of the code, and k is a factor defined as follows:

- k = 1.0 for round-bilge ships;
- k = 0.7 for a ship with sharp bilges;
- k as given by Table 2.6 of the code for a ship having bilge keels, a bar keel or both.

By using the factor k, the IMO code considers indirectly the effect of damping on stability. More specifically, it acknowledges that sharp bilges, bilge keels and bar keels reduce the roll amplitude. By assuming that the ship is subjected to the wind gust while heeled windward from the static angle, the dynamical effect appears more severe.

The factor r is calculated from

$$r = 0.73 + 0.6\frac{OG}{Tm} \qquad (2.6)$$

where OG is the distance between the waterline and the centre of gravity, positive upwards. The factor s is given in Table 2.7 of the code, as a function of the roll period, T . The code prescribes the following formula for calculating the roll period, in seconds,

$$T = \frac{2GM}{\sqrt{GM_{eff}}} \qquad (2.7)$$

where

$$C = 0.373 + 0.023 + \left(\frac{B}{T_m}\right) - 0.043\left(\frac{L_{WL}}{100}\right) \qquad (2.8)$$

The code assumes that the lever arm of the wind gust is

$$\ell_{w2} = 1.5\,\ell_{w1} \quad (2.9)$$

Plotting the curve of the arm ℓ_{w2} we distinguish the areas a and b. The area b is limited to the right at 50° or at the angle of flooding, whichever is smaller. The area b should be equal to or greater than the area a. This provision refers to dynamical stability. When applying the criteria described above, the Naval Architect must use values corrected for the free surface effect, which is GM eff and GZ_{eff}. The free-surface effect is calculated for the tanks that develop the greatest moment, at a heel of 30°, while half full. The code prescribes the following equation for calculating the free-surface moment

$$M_F = vb\gamma k\sqrt{\delta} \quad (2.10)$$

where v is the tank capacity in m^3, b is the maximum breadth of the tank in m, γ is the density of the liquid in t m^{-3}, δ is equal to the block coefficient of the tank, $v/b\ell h$, with h, the maximum height and, the maximum length, and k, a coefficient given in Table 2 below as function of b/h and heel angle. The contribution of small tanks can be ignored if $M_F/\Delta_{min} < 0.01$ m at 30°. The code specifies the loading cases for which stability calculations must be performed. For example, for cargo ships the criteria shall be checked for the following four conditions:

1. Full-load departure, with cargo homogeneously distributed throughout all cargo spaces.
2. Full-load arrival, with 10% stores and fuel.
3. Ballast departure, without cargo.
4. Ballast arrival, with 10% stores and fuel.

B/d	X_1
≤ 2.4	1.0
2.5	0.98
2.6	0.96
2.7	0.95
2.8	0.93
2.9	0.91
3.0	0.90
3.1	0.88
3.2	0.86
3.4	0.82
≥ 3.5	0.80

Figure 2. 4: Values of factor X_1 (Biran, 2003)

C_B	X_2
≤ 0.45	0.75
0.50	0.82
0.55	0.89
0.60	0.95
0.65	0.97
≥ 0.70	1.00

Figure 2. 5: Values of factor X2 (Biran, 2003)

$\frac{A_k \times 100}{L_{WL} \times B}$	k
0	1.0
1.0	0.98
1.5	0.95
2.0	0.88
2.5	0.79
3.0	0.74
3.5	0.72
≥ 4.0	0.70

Figure 2. 6: Values of factor k (Biran, 2003)

T	s
≤ 6	0.100
7	0.098
8	0.093
12	0.065
14	0.053
16	0.044
18	0.038
≥ 20	0.035

Figure 2. 7: Values of factor s (Biran, 2003)

2.1.3. Curves of Static Stability

Since the stability of a ship can be directly commented on by the nature and value of its metacentric height (GM), a direct method to track the stability of a ship for a range of heel angles would be, to generate a curve that relates this parameter to the angle of heel. Since metacentric height is directly related to the righting lever (GZ) and angle of heel, the curve of static stability is a plot between the righting lever and angle of heel.

Figure 2.8 below is the graph that plotted assuming that the ship is in static condition. Some of the important information that can be derived from any GZ curve of a ship are discussed below:

If the curve intersects the origin, it means that there is no righting lever when the ship is upright. In other words, the ship has inherent positive initial stability.

The maximum righting lever (GZ_{MAX}), represented by point 'B' in the graph is proportional to the largest static heeling moment that is required to bring the ship back to its upright position. The value of maximum GZ and the angle at which it occurs, are important values. In other words, the maximum righting lever when multiplied with the displacement of the ship, gives us the value of the maximum heeling moment that the ship can sustain without capsizing. Because, beyond this angle, the righting lever (in other words, the stability) of the ship decreases drastically.

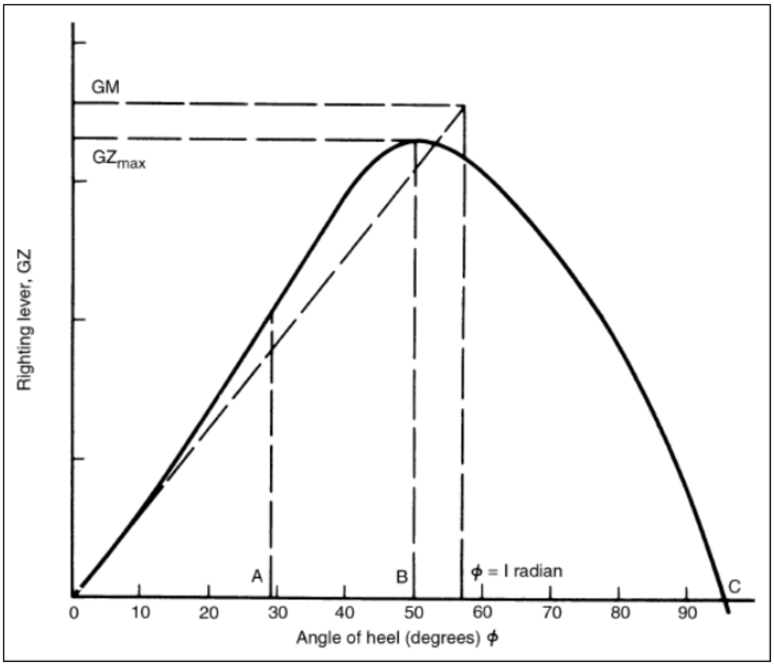


Figure 2. 8: Static Stability Curve / GZ Curve of a Ship. (Chakraborty, 2017)

The point where the GZ curve meets the horizontal axis (shown as 'C' in the figure 2.8), is called the point of vanishing stability, since righting lever becomes zero at this point. So, any heel beyond this angle would result in a condition of negative stability. The distance between the origin and point of vanishing stability is called the range of stability of a ship. In the above case, the range of stability is from 0 degrees to some angle above 90 degrees.

As the angle of heel increases, there comes a point when the deck of the ship immerses. This angle is called the angle of deck immersion, and the corresponding point on the curve is called point of inflection. How do you recognise this point just by looking at a GZ curve? To know this, let's first understand the phenomenon of deck immersion from a stability point of view. When the deck of a ship immerses, the rate of shift of center of buoyancy (and also the righting lever) with further heeling changes. This results a change in concavity of the curve. This can clearly be noted at point 'A' in the above curve. (Chakraborty, 2017).

Point of inflection does not play an important role in operational purposes, but it helps designers to make preliminary predictions regarding what changes in stability would be brought about if the design of a hull-form is altered.

The total area under the static stability curve gives the amount of energy that the ship can absorb from external heeling forces (winds, waves, weight shifts, etc.) till it capsizes. Thus, it should not be assumed that a ship is stable enough only if the value of the maximum GZ is high. A GZ curve with a very high maximum value might not have the sufficient area, and as a result, the ship will capsize easily because it wouldn't be able to absorb enough energy before capsizing.

If a tangent is drawn to the GZ curve at the origin, and an ordinate is drawn at 57.3 degrees (1 Radian), then the point of intersection of the tangent and the ordinate would give the value of the initial metacentric height of the ship, as shown in the above figure. This can be proved mathematically, but instead of going into that, we will understand how this important property of the curve is applied for practical purposes.

The above theory implies, that steeper initial slope of the GZ curve would mean that the ship has more initial stability. However, larger initial stability does not imply larger values maximum righting lever and range of stability.

2.2. Roll-on/roll-off Ship

Roll-on/roll-off (RORO or ro-ro) ships are vessels intended for loading and unloading the cargo by Roll on/Roll off (RO/RO) (DNVGL, 2017), such as cars, truck, trailer truck, motorcycle. Roll on/Roll off means that the vehicles are driven on and off the ship on their own wheels or using a platform vehicle.

RORO vessels have either built-in or shore-based ramps that allow the cargo to be rolled efficiently on and off the vessel when in port. While smaller ferries that operate across rivers and other short distances often have built-in ramps, the term RORO is generally reserved for large oceangoing vessels. The ramps and doors may be located in stern, bow or sides, or any combination thereof.

A ro-ro ship offers a number of advantages over traditional ships. Some of the advantages are as follows (Kantharia, 2019):

- For the shipper, the advantage is speed. Since cars and Lorries can drive straight on to the ship at one port and then drive off at the other port within a few minutes of the ship docking, it saves a lot of time of the shipper.
- It can also integrate well with other transport development, such as containers. The use of Customs-sealed units has enabled frontiers to be crossed with the minimum of delay. Therefore, it increases the speed and efficiency for the shipper.
- The ship has also proved extremely popular with holidaymakers and private car owners. It has significantly contributed to the growth of tourism. A person

can take his car from one country to another by sea with the help of a ro-ro vessel.

ROPAX is an acronym for roll on/roll off a passenger. It is a ro-ro vessel built for freight vehicle transport with passenger accommodation. The vessels with facilities for more than 500 passengers are often referred to as cruise ferries (Kantharia, 2019).

RoPax is basically used for short sea transport. These vessels comply with both the international standards which apply to a passenger ship as well as to a Ro-Ro.

Related to the vehicles entering into the ferry port area to the ship, these activities are regulated in the *Peraturan Direktur Jenderal Perhubungan Darat Nomor: SK. 2681/AP.005/DRJD/2006*, concerning the operation of ferry ports.

For passenger vehicles, the following are port service procedures:

1. Service User queuing up to wait their turn or take a queue number, if any.
2. The clerk at the port entrance gives a queue number (if any).
3. All passengers get off the vehicle, report to the port clerk then wait for the queue.
4. Vehicles passengers pay for integrated tickets for passengers and vehicles.
5. Passenger vehicles heading to the parking lot are ready to be loaded and parked according to the queue.
6. The shipping clerk records the identity of the vehicle and cuts the ticket.
7. Vehicles comes through MB / Pontoon enter ships directed by officers.
8. Inside the ship, a ship clerk who will convey things that need attention regulates the vehicle.

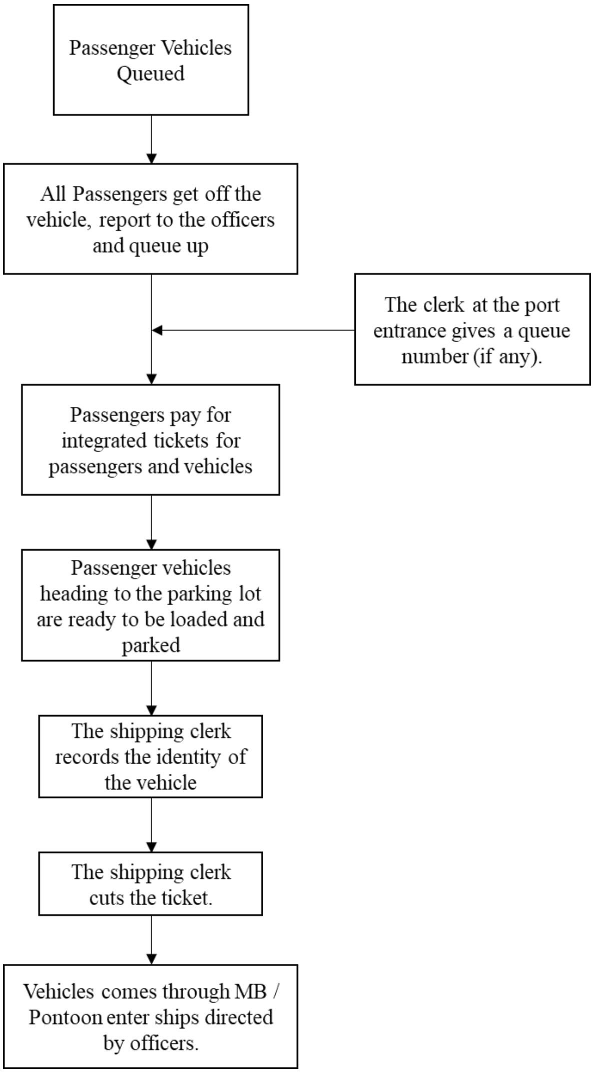


Figure 2. 9: Passenger Vehicle Service Procedure Flow Chart (Komite Nasional Keselamatan Transportasi, 2016)

As for Goods vehicles and heavy equipment transportation vehicles, the port service procedures is as follows:

1. Officers reported the arrival of a loaded truck.
2. The clerk records then is given the queue number if there is and according to the turn to be weighed.
3. If tonnage exceeds the weight of the cargo, in accordance with applicable regulations, the truck is issued to reduce the load. For the appropriate tonnage, proof of weight (receipt) can be made.
4. If the load does not exceed the specified weight, the truck has the right to buy crossing tickets.

5. Service users pay fees through production counters deposited to authorized officers.
6. Proof of payment received by service users.
7. Vehicle going to the dock.
8. Proof of scales and ticket pieces are taken at the same time as MB is ready to board the ship.

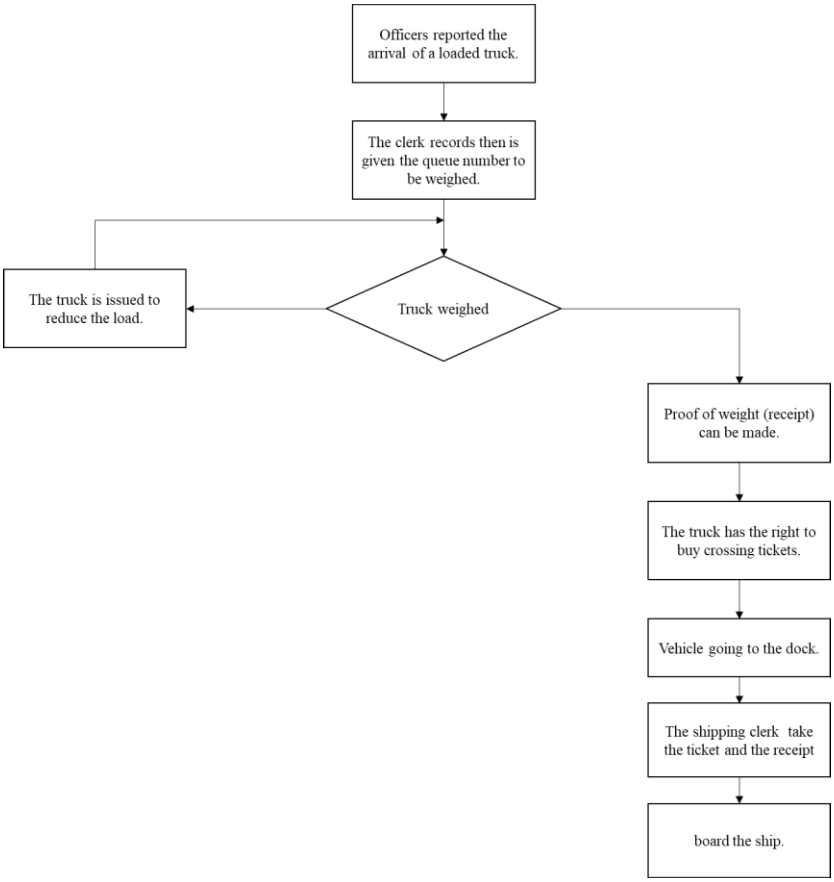


Figure 2. 10: Loaded Truck Vehicle Service Procedure Flow Chart (Komite Nasional Keselamatan Transportasi, 2016)

2.3. Maxsurf

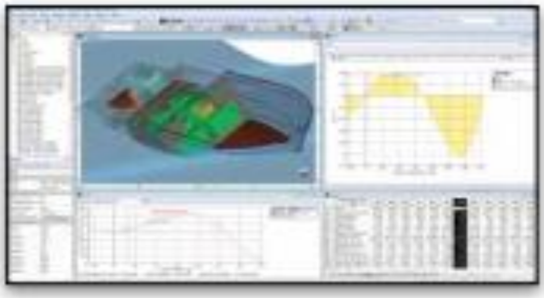
Maxsurf is a powerful three-dimensional surface modelling system for use in the field of marine design. It provides you with a clear and familiar environment in which to work, allowing for systematic experimentation and rapid optimisation of any new design. Maxsurf's multiple surface capabilities, allowing any number of surfaces to be modelled in any given design, offer scope for the creation of a wide range of hull forms. Combined with the built-in hydrostatic calculations, you have the tools to experiment with shapes and explore design parameters.

Highly accurate output is produced in the form of hull lines, transfer files for other programs, and comprehensive offsets tables. Data transfer to other programs in the

Maxsurf suite is from a Maxsurf design file, alleviating the need for the re-entry of data once a design has been finalized, and removing the possibility of loss of accuracy through the use of incomplete hull offset files.

One of the Maxsurf product is Maxsurf Stability. The Maxsurf Stability module provides fast, graphical, and interactive calculation of intact and damaged stability and strength for all types of Maxsurf designs. Once a design is created using Modeler, its stability and strength characteristics can be assessed using the Stability analysis module. The Stability analysis module provides a range of powerful analysis capabilities to handle all types of stability and strength calculations. Precise calculations are performed directly from the trimmed Maxsurf Nurb surface model without the need for offsets or batch file preparation. All functions within Stability are performed using a graphical multi-window environment consistent with all other Maxsurf modules. Data is displayed simultaneously in graphical and tabular form and is automatically updated when changes are made and as the analysis progresses. An integrated load case editor makes setting up any number of loading conditions simple and error free. Copying and pasting data to and from spreadsheets also makes it easy to prepare complex loading schedules in other programs and run them in Stability.

Load cases can also be saved and reused with various design configurations. Tank and compartment modeling are integrated within Stability, allowing you to quickly and easily define the vessel's tank and compartment layout. More complex compartments can be defined using surfaces created in Maxsurf Modeler. Tanks are automatically included in the weight schedule and as parametric objects they are automatically updated if the hull shape is changed as the design progresses.



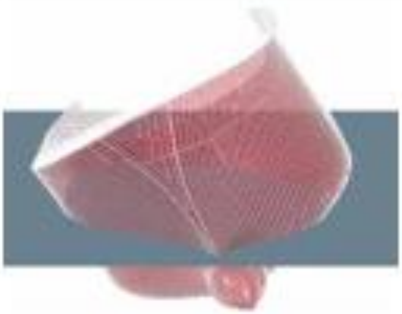


Figure 2. 11: Maxsurf Stability Module (Maxsuft Product Brochure)

After an analysis is completed, all results are presented in either tabular or graphical form. You can click on any graph and move the cursor to obtain precise values at any location. You can also choose how tables are displayed, which columns are visible, and sort results by any column.

An automatically formatted on-screen report window accumulates the results of analysis to help prepare a stability book for your vessel. Descriptions, tables, graphics, and graphs are automatically inserted and can be re-formatted or deleted at any time. You can also enter notes into the report and cut and paste graphics from the Stability module, other MAXSURF modules, or any other application. The entire report can be generated using a Microsoft Word template document.

2.4. Visual Basic for Application

Microsoft Excel includes a comprehensive macro programming language called Visual Basic for Application (VBA) (Rado, 2018). This programming language provides you with at least three additional resources:

1. Automatically drive Excel from code using Macros. For the most part, anything that the user can do by manipulating Excel from the user interface can be done by writing code in Excel VBA.
2. Create new, custom worksheet functions.
3. Interact Excel with other applications such as Microsoft Word, PowerPoint, Internet Explorer, Notepad, etc.

VBA is an event-driven programming language from Microsoft that is now predominantly used with Microsoft office applications such as MS-Excel, MS-Word, and MS-Access. (Tutorials Point (I) Pvt. Ltd., 2016).

It helps techies to build customized applications and solutions to enhance the capabilities of those applications. The advantage of this facility is that you need not have visual basic installed on our PC, however, installing Office will implicitly help in achieving the purpose.

The usefulness of Microsoft Excel is not fixed on the things above, but can cover even more. Excel is used for a variety of things, and everyone has different needs and expectations about Excel. One thing that almost every reader has in common is the need to automate some aspects of Excel. That's what users can get with VBA (Broexcel, 2019).

While users cannot directly manipulate the main Excel software through VBA, they can, however, master the art of making macros to optimize their time in Excel. There are two ways to make Excel macros (CFI Education Inc., 2019).

The first method is to use the Macro Recorder. After activating the recorder, Excel will record all the steps a user makes and save it as a “process” known as a macro. When the user ends the recorder, this macro is saved and can be assigned to a button that will run the exact same process again when clicked. This method is relatively simple and requires no inherent knowledge of the VBA code. This method will work for simple processes.

However, the downfall of this method is that it is not very customizable, and the macro will mimic the user's input exactly. By default, recorder macros also use absolute referencing instead of relative referencing. This means that macros made in this way are very hard to use with variables and "smart" processes. The second and more powerful method of creating an Excel macro is to code one using VBA.

CHAPTER III

RESEARCH METHODOLOGY

3.1. Introduction

This section describes the planned research activities to be carried out. The research activities are arranged in a structured and sequential manner, so that a methodology flowchart is made, and also the timeline of this study.

3.2. Flowchart of Methodology

As stated in chapter 1 to answer the problems that above, the research method used by the writer is analysis. The research implementation can be seen in the flow diagram as shown in Figure 3.1. below.

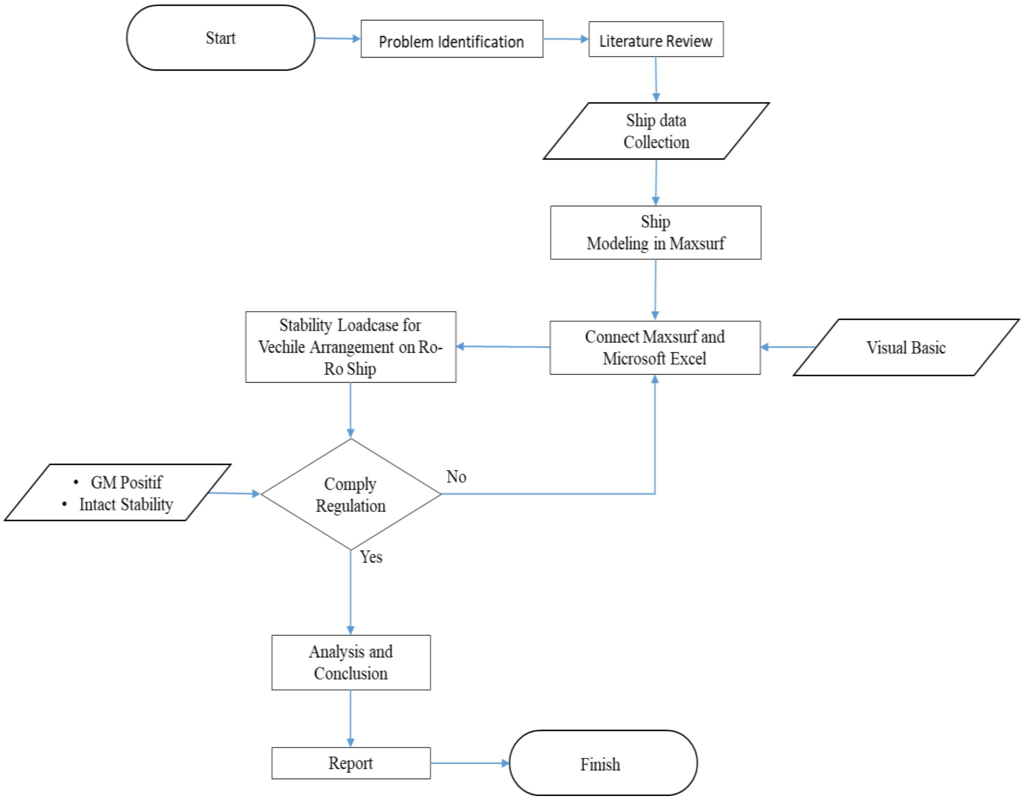


Figure 3. 1: Research Flow Diagram

3.3. Ship Data Collection

This step is carried out before analyzing the stability of the ship. Ship data collected is used as the main data for making the ship model in Maxsurf. In the preparatory step is expected all the data is easy to obtain in order to make it easier to do the analysis. Data needed include:

1. Principal Dimension
2. Lines plan
3. General arrangement
4. Vehicle arrangement planning
5. Etc.

3.4. Ship Modeling on Maxsurf

This step is the step taken before doing stability analysis on the ship, after all the vessel data collected is enough, then this step can be implemented. Making Lines Plan is the main key to the success of ship design before the model is carried out hydrodynamic analysis, structural strength and further detail. Often this model and analysis is always changing because of the incompatibility between design and analysis, so that the design process can be described as a complementary spiral design.

3.5. Connecting Maxsurf and Microsoft Excel

After the previous step is done, the next is to connect with Microsoft Excel software. Microsoft Excel is used as input for Maxsurf software, as well as to regulate variations in vehicle arrangement within the ship. The input that have been send to Maxsurf will be analyzed. After that, the result of the analysis will be send again to Microsoft Excel to be displayed. The process of connecting is done by coding with Visual Basic as an medium. This process is illustrated in the following Figure 3.2.

The process starts with making a ship model on Maxsurf as illustrated by figure (c), after that the connecting process with visual basic is done as an intermediary, as illustrated in figure (b). After the previous process is complete and both software can be connected, several simulations are carried out on the relationship. The simulation is done by inputting the load case variation from the vehicle arrangement on the ro-ro ship. Feedback obtained from Maxsurf (c) and Microsoft Excel (a) is used for evaluation to comply with regulations.

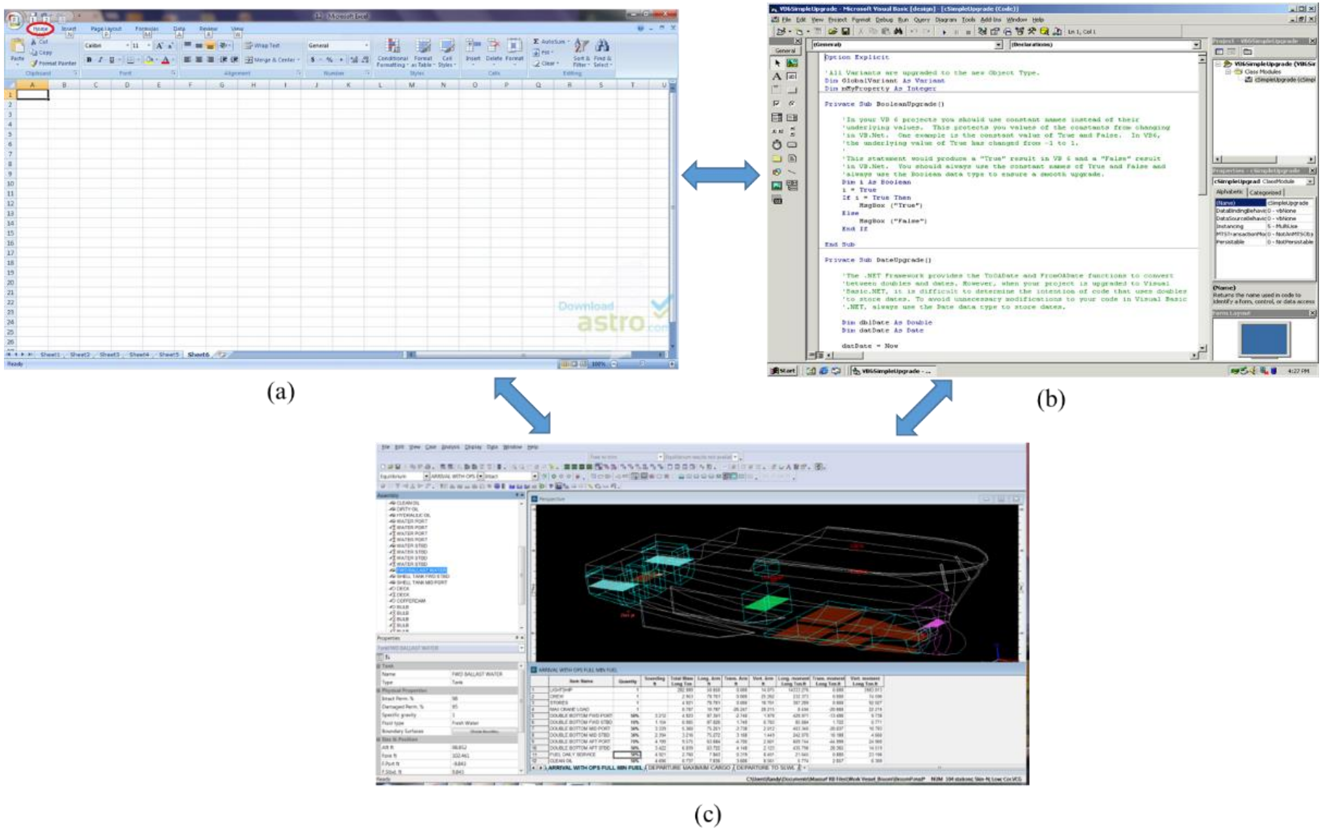


Figure 3. 2: Illustration of The Process of Connecting Maxsurf with Microsoft Excel

(a) Microsoft Excel, (b) Visual Basic, (c) Maxsurf Stability

This process began by creating an interface in Microsoft Excel, then started coding in Microsoft Excel through Visual Basic so that Microsoft Excel could send commands to Maxsurf. Whether it's a command to open files, load cases, or start analysis.

3.5.1. Creating Interfaces in Microsoft Excel

The purpose of this process is to create interfaces in Microsoft Excel, which are needed to input data such as load case, number of vehicles, placement, etc. The input will later be sent to Maxsurf for later processing.

The first thing that needs to be displayed in Microsoft Excel as an interface is the load case. Load case interfaces in Microsoft Excel are made according to the load cases that Maxsurf has. The load case on Maxsurf can be seen in the following Figure 3.3.

	Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
1	Lightship	1	500,000	500,000			15,550	0,000	2,500	0,000	User Specifie
2	Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000	User Specifie
3	Truk Besar 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
4	Truk Besar 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
5	Truk Besar 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
6	Truk Besar 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
7	Truk Besar 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
8	Truk Besar 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
9	Truk Besar 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
10	Truk Besar 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
11	Mobil 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
12	Mobil 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
13	Mobil 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
14	Mobil 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
15	Mobil 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
16	Mobil 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
17	Mobil 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
18	Mobil 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
19	Penumpang	112	0,100	11,200			5,700	0,000	5,600	0,000	User Specifie
20	T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	**9,878**	21,000	-1,750	0,392	0,000	Maximum
21	T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	**9,878**	21,000	1,750	0,392	0,000	Maximum
22	T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	**13,171**	16,800	-1,750	0,392	0,000	Maximum
23	T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	**13,171**	16,800	1,750	0,392	0,000	Maximum
24	T.A.T. (C)	100%	22,239	22,239	22,239	**22,239**	3,673	0,000	1,961	0,000	Maximum
25	T.A.B. No.1 (PS)	100%	27,440	27,440	26,771	**26,771**	28,783	-1,745	0,401	0,000	Maximum
26	T.A.B. No.1 (SB)	100%	27,440	27,440	26,771	**26,771**	28,783	1,745	0,401	0,000	Maximum
27	T.A.B. No.2 (PS)	0%	21,442	0,000	20,919	**0,000**	4,752	-1,168	0,242	0,000	Maximum
28	T.A.B. No.2 (SB)	0%	21,442	0,000	20,919	**0,000**	4,752	1,168	0,242	0,000	Maximum
29	T.C.H.	**0%**	42,136	0,000	41,108	0,000	37,842	0,000	0,286	0,000	Maximum
30	T.M.K.	0%	4,057	0,000	4,410	**0,000**	9,004	-0,857	0,000	0,000	Maximum
31	T. Bilga	0%	4,410	0,000	4,410	**0,000**	9,004	0,857	0,000	0,000	Maximum
32	**Total Loadcase**			**628,242**	**214,585**	**121,879**	**16,295**	**0,000**	**2,233**	**0,000**	
33	**FS correction**								**0,000**		
34	**VCG fluid**								**2,233**		

Figure 3. 3: Maxsurf Load case

However, what is made in this interface is only the load of vehicles and passengers, without making tank loads, such as ballast tanks, fuel tanks, etc. This is because this research only focuses on vehicle and passenger loads as the variable. The interface for the load case on Microsoft Excel can be seen in figure 3.4 below.

	Item Name	Quantity	Unit Mass (Ton)	Total Mass (Ton)	Section	Long. Arm (m)	Trans. Arm (m)	Vert. Arm (m)
	INPUT							
1.	Truk Besar 1	1	2000	2000	Section 1	4,45	0	4,7
	Truk Besar 2	1	1400	1400	Section 2	14,15	0	4,7
	Truk Besar 3	1	1500	1500	Section 3	22,65	2,97	4,7
	Truk Besar 4	1	1550	1550	Section 4	22,65	0	4,7
	Truk Besar 5	1	2100	2100	Section 5	22,65	2,97	4,7
	Truk Besar 6	1	0	0	Section 2	14,15	0	4,7
	Truk Besar 7	1	0	0	Section 7	31,15	0	4,7
	Truk Besar 8	1	0	0	Section 8	31,15	2,97	4,7
2.	Mobil 1	1	1000	1000	Section 6	31,15	2,97	4,7
	Mobil 2	1	500	500	Section 2	14,15	0	4,7
	Mobil 3	1	600	600	Section 4	22,65	0	4,7
	Mobil 4	1	0	0	Section 1	4,45	0	4,7
	Mobil 5	1	0	0	Section 3	22,65	2,97	4,7
	Mobil 6	1	0	0	Section 7	31,15	0	4,7
	Mobil 7	1	0	0	Section 6	31,15	2,97	4,7
	Mobil 8	1	0	0	Section 5	22,65	2,97	4,7
	Penumpang	121	0	0		0	0	0

Figure 3. 4: Microsoft Excel Interface for Load Cases

Because the load case does not have a volume unit, the rows for volume units are replaced by a section that is used to indicate the placement of vehicles on the ship. In determining these placements are added also general arrangement drawing of the ship, which is used as a reference. The drawing is changed by adding several sections which will later become the area of placement of the vehicle. The results of the drawing changes are then entered into Microsoft Excel, as can be seen in the following Figure 3.5.

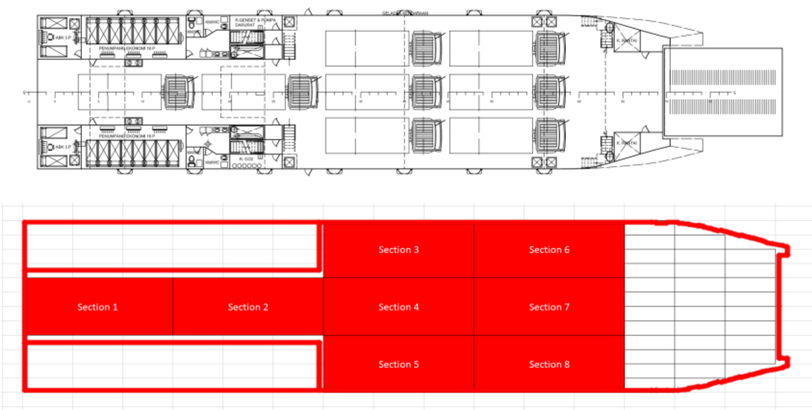
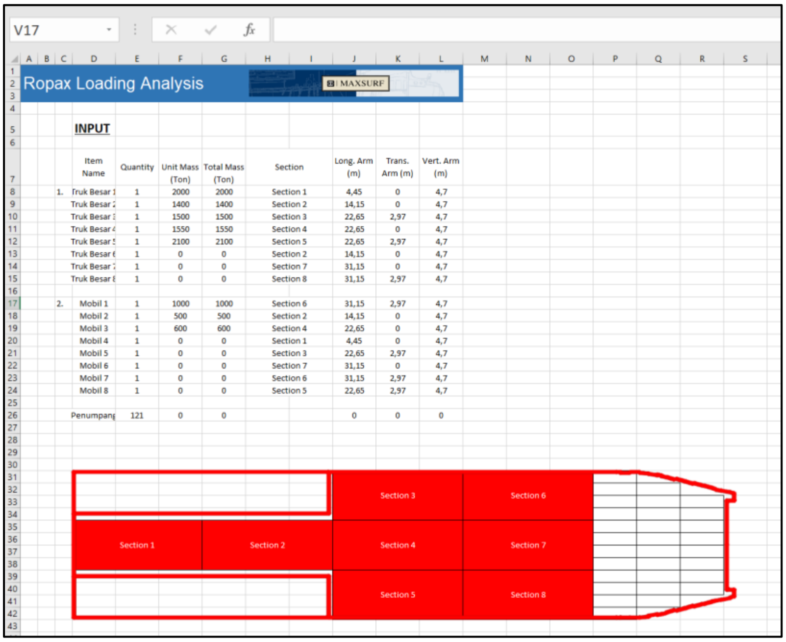


Figure 3. 5: Placement Area for Vehicle,

General Arrangement (Above) and Excel Interfaces (Below)

After all these things have been done, the results of the interface created are in Figure 3.6 below. The interface contains all the things needed to enter inputs which will be integrated with Maxsurf for processing.



Ropax Loading Analysis

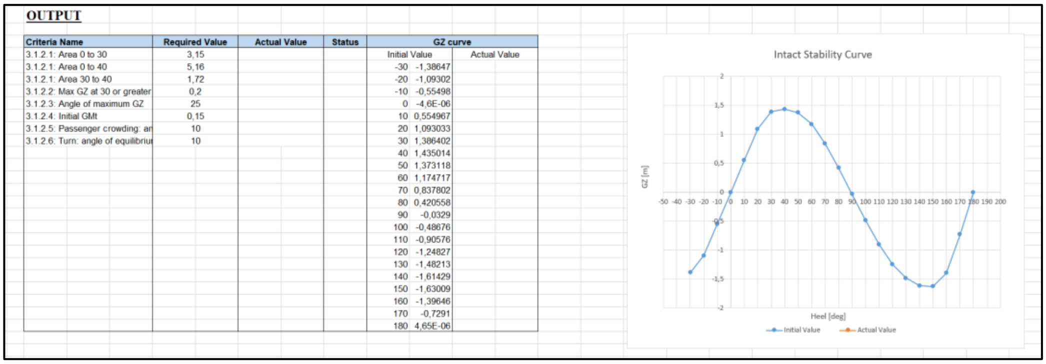
MAXSURF

INPUT

	Item Name	Quantity	Unit Mass (Ton)	Total Mass (Ton)	Section	Long. Arm (m)	Trans. Arm (m)	Vert. Arm (m)
1.	Truk Besar 1	1	2000	2000	Section 1	4,45	0	4,7
	Truk Besar 2	1	1400	1400	Section 2	14,15	0	4,7
	Truk Besar 3	1	1500	1500	Section 3	22,65	2,97	4,7
	Truk Besar 4	1	1550	1550	Section 4	22,65	0	4,7
	Truk Besar 5	1	2100	2100	Section 5	22,65	2,97	4,7
	Truk Besar 6	1	0	0	Section 2	14,15	0	4,7
	Truk Besar 7	1	0	0	Section 7	31,15	0	4,7
	Truk Besar 8	1	0	0	Section 8	31,15	2,97	4,7
2.	Mobil 1	1	1000	1000	Section 6	31,15	2,97	4,7
	Mobil 2	1	500	500	Section 2	14,15	0	4,7
	Mobil 3	1	600	600	Section 4	22,65	0	4,7
	Mobil 4	1	0	0	Section 1	4,45	0	4,7
	Mobil 5	1	0	0	Section 3	22,65	2,97	4,7
	Mobil 6	1	0	0	Section 7	31,15	0	4,7
	Mobil 7	1	0	0	Section 6	31,15	2,97	4,7
	Mobil 8	1	0	0	Section 5	22,65	2,97	4,7
	Penumpang	121	0	0		0	0	0

Figure 3. 6: Example of Input Interface for Maxsurf in Microsoft Excel

After that a section that is used as a user interface to display output from the results of stability analysis carried out by Maxsurf is made, that is the output section in Microsoft Excel. The things that need to be displayed are the criteria for rules that need to be compliance, the value of the criteria, the value of the results of the analysis, the status of compliance, the data to display the GZ curve consisting of the heel degree and GZ point, and the graph to display the GZ curve. The section can be seen in the following Figure 3.7.



OUTPUT

Criteria Name	Required Value	Actual Value	Status	GZ curve		
3.1.2.1: Area 0 to 30	3,15			Initial Value		Actual Value
3.1.2.1: Area 0 to 40	5,16			-30	-1,38647	
3.1.2.1: Area 30 to 40	1,72			-20	-1,09302	
3.1.2.2: Max GZ at 30 or greater	0,2			-10	-0,55498	
3.1.2.3: Angle of maximum GZ	25			0	-4,6E-06	
3.1.2.4: Initial GMt	0,15			10	0,554967	
3.1.2.5: Passenger crowding: an	10			20	1,093033	
3.1.2.6: Turn: angle of equilibriu	10			30	1,386402	
				40	1,435014	
				50	1,373118	
				60	1,174717	
				70	0,837802	
				80	0,420558	
				90	-0,0329	
				100	-0,48676	
				110	-0,90576	
				120	-1,24827	
				130	-1,48213	
				140	-1,61429	
				150	-1,63009	
				160	-1,39646	
				170	-0,7291	
				180	4,65E-06	

Figure 3. 7: Output Section in Microsoft Excel

3.5.2. Using Visual Basic to Connecting Maxsurf and Microsft Excel

Microsoft Excel and Maxsurf connection is done by using Visual Basic fo Aplication as an intermediary to make various kinds of commands that will be sent to Maxsurf from Microsoft Excel in the form of programming languages (codings).

The way to use visual basic on Microsoft products (which in this case using Microsoft Excel) is on the option developer. The developer option in Microsoft Excel can be seen in figure 3.8.

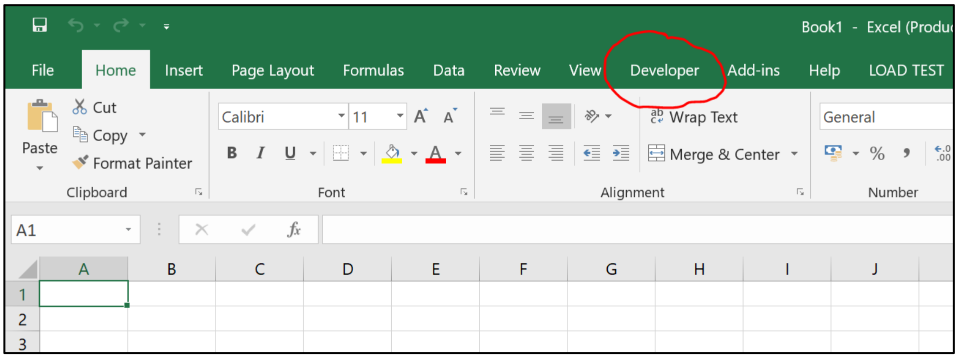


Figure 3. 8: Developer Option in Microsoft Excel

However, this developer option is not normally displayed in tabs that are in Microsoft Excel. For that reason, the first thing to do is to bring up an option developer in Microsoft Excel. The steps to display the Developer Tab on Excel are as follows:

1. Open the Microsoft Office Excel Program
2. Select File Menu
3. Select Options (as seen in figure 3.9)
4. After that the Excel Options dialog box will appear. Select Customize Ribbon.
5. If in the Customize Ribbon section has not displayed the Developer option, see the Choose commands from section and select Main Tabs.
6. Click the Developer Section then click add. (as seen in figure 3.10)

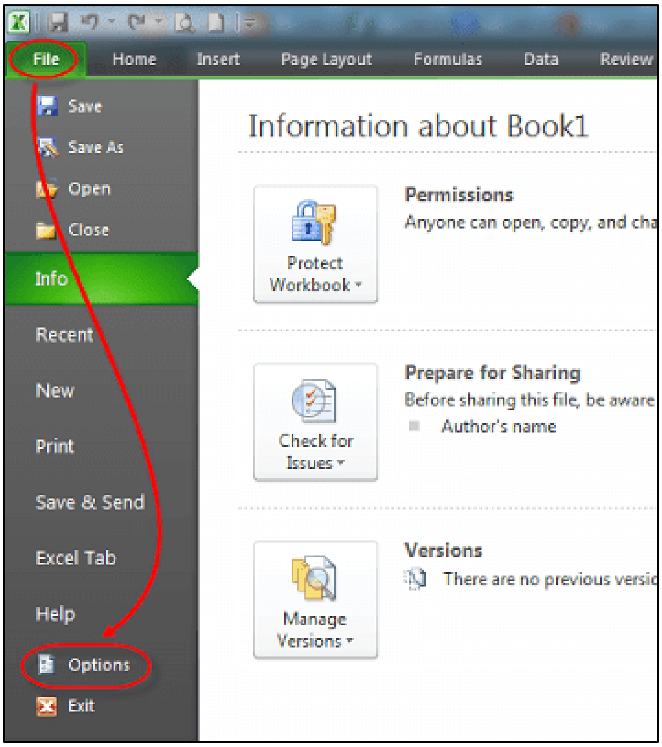


Figure 3. 9: File Menu on Microsoft Excel

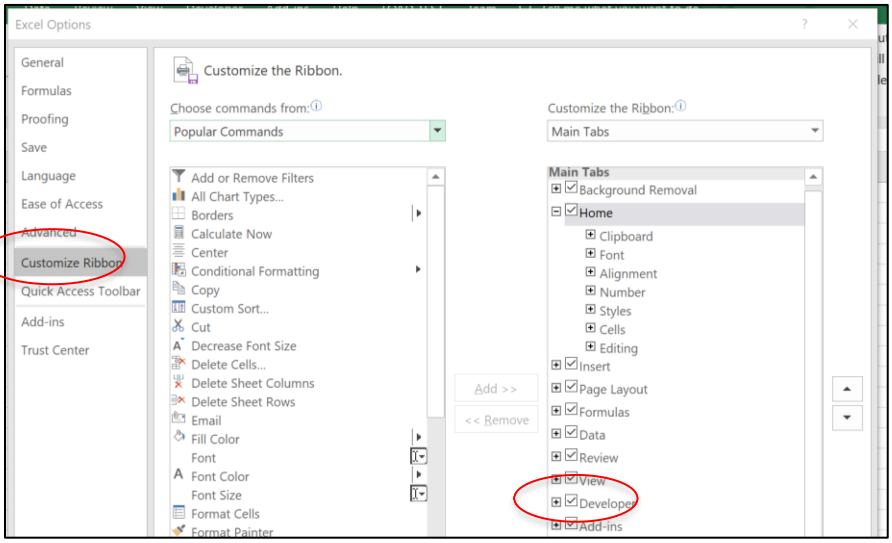


Figure 3. 10: How to Enable Developer Option on Microsoft Excel

After the option developer can appear, we can use Visual Basic in order to send commands to Maxsurf by opening the Visual Basic dialog box on the sub-option on the developer option.

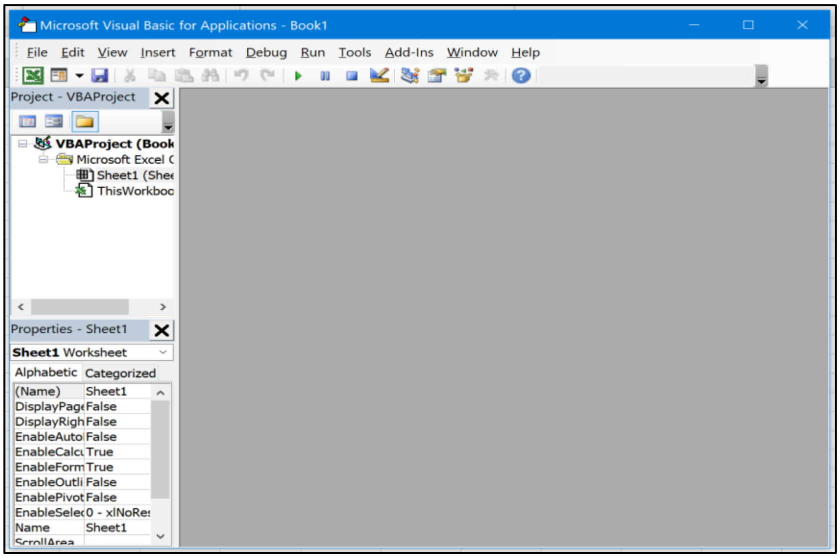


Figure 3. 11: Visual Basic Dialog Box

3.5.3. Coding Command in VBA

After the Visual Basic dialog box opens, we can start connecting Maxsurf and Microsoft Excel. To be able to execute the commands that needed, so making a button as the command controller is needed. The steps taken are as follows.

1. Click on the DEVELOPER tab
2. Click on INSERT drop down box under controls ribbon bar
3. Select a command button as shown in the following figure 3.12.

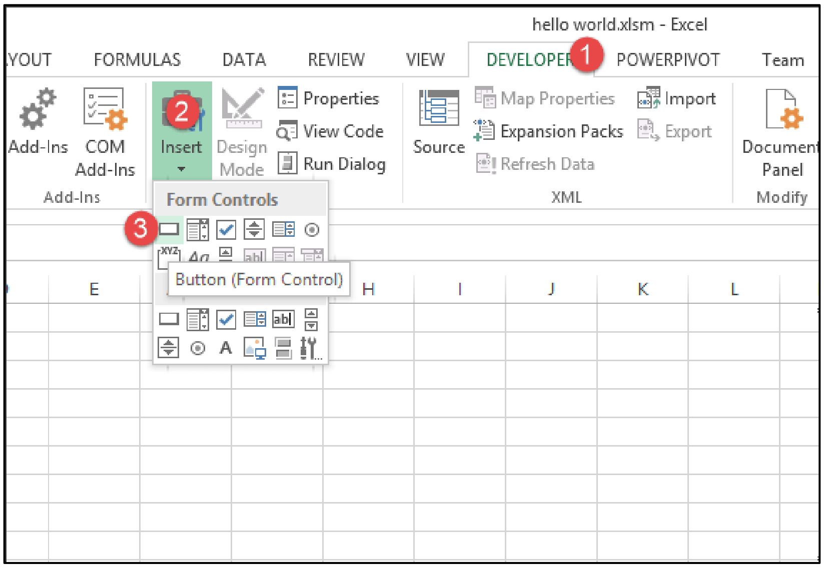


Figure 3. 12: Button for Visual Basic

After the button is finished, the next thing to do is assign the button to our visual basic code. The way to do this is to right-click on the button we have made, then click assign macro. After we assign macros, the dialog box from Visual Basic will display a new sub-line code. After that the command coding on visual basic can be done.

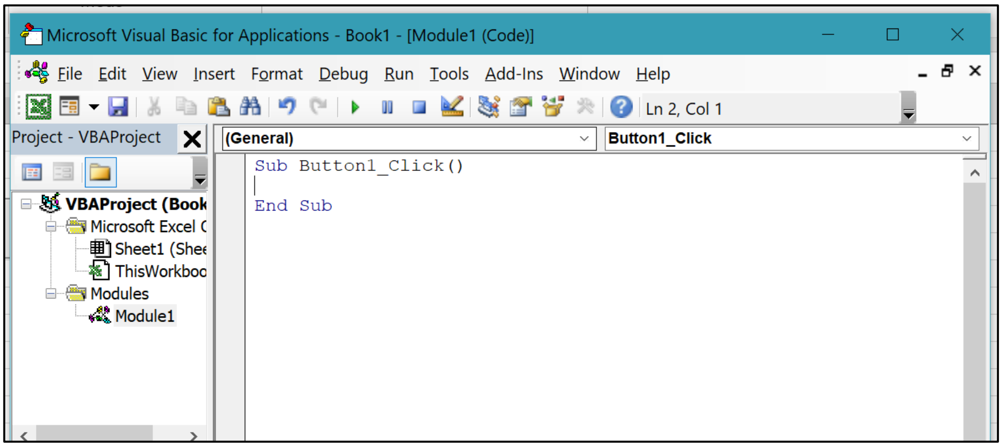


Figure 3. 13: Sub-coding line on Visual Basic

To be able to send commands to Maxsurf, various types of command codes on Maxsurf must be known. However, there is no documentation that explains these codes, so finding these command codes is quite difficult. The way to determine these codes is to look at the Excel file in the Maxsurf program itself. Then from the file we can learn the types of codes used.

In coding, first a variable declaration is needed. Variables are places in computer memory that are named (as identifiers) and are allocated to hold data. According to the data collected, the variable must have a data type that matches the contents.

To declare a variable, DIM, PRIVATE, STATIC, and PUBLIC commands are used by declaring the variable name and data type at the beginning of the procedure. declaring variables in this process is:

Public hydromaxApp As New BentleyStability.Application

The first code that needs to be found is the code to open the Maxsurf program and load the design file that we made in the previous process. The code for doing this is:

hydromaxApp.Design.Open ("file location")

After that the coding results are tested by clicking the button that was made at the beginning of the process, if the process is successful then the next process is coding to determine the section area for vehicle placement.

For this need one more button is made and assigned to the new sub-line code, after that the code is written in the following format:

If Cells(8, 8) = "Section 1" Then

```
Cells(8, 10) = 4.45
Cells(8, 11) = 0
Cells(8, 12) = 4.7
ElseIf Cells(8, 8) = "Section 2" Then
Cells(8, 10) = 14.15
Cells(8, 11) = 0
Cells(8, 12) = 4.7
....
ElseIf Cells(8, 8) = "Section 8" Then
Cells(8, 10) = 31.15
Cells(8, 11) = 2.97
Cells(8, 12) = 4.7
Else
Cells(8, 10) = 0
Cells(8, 11) = 0
Cells(8, 12) = 0

End If
```

The above code can be interpreted "if cells (8.8) are filled with Section 1, then cell (8.10) will be filled with 4.45, cells (8.11) will be filled with 0, and cells (8.12) will fill 4.7, but if it is filled with Section 2, it will change according to the above, and if it is filled in other than the existing ones (Section 1, Section 2, ..., Section 8) then the values are filled in cell (8,10), cells (8,11), cells (8 , 12) will be 0.

Cells (8,10), cells (8,11), and cells (8,12) as in figure 4.2 above contain the coordinates of the loading of the vehicle on board, by taking the AP point as a reference 0 from that coordinate. So, in placing the vehicle, coordinates are made according to the reference point. Longitudinal arm (cells (8,10)) is the long coordinate of the reference point, transverse arm (cells (8,11)) is the width coordinate of the reference point, and vertical arm (cells (8,12)) is the high coordinate of the point reference. By filling in all the coordinates, the coordinates of the ship will be formed.

In one row, there are eight possible laying on each section in the area of the vessel, therefore every single row has eight branching logic as above. This is also applying to the row below it, and also applies to truck and car vehicles. Then the results of the coding are tested, and if successful the next process can be carried out.

The next process is the coding for the input of load cases that have been created in Microsoft Excel, to Maxsurf. Just as before, the first one to be created is a new button and assign it to the new sub-line code. After that enter the code in the format as follows.

```
hydromaxApp.Design.LoadCases.Item(4).MassItemByName("Item
name").Quantity = Range("E8").Value
hydromaxApp.Design.LoadCases.Item(4).MassItemByName("Item
name").Mass = Range("F8").Value
hydromaxApp.Design.LoadCases.Item(4).MassItemByName("Item name").LCG
= Range("J8").Value
```

```
hydromaxApp.Design.LoadCases.Item(4).MassItemByName("Item name").TCG
= Range("K8").Value
hydromaxApp.Design.LoadCases.Item(4).MassItemByName("Item name").VCG
= Range("L8").Value
```

The function of the code above is to change the loadcase value that is in maxsurf. If the change is quantity, the code that must be entered is "Quantity" and so on. For the amount to be changed from the loadcase, the value is filled in range (E8) or cells (5.5). After that the results of the coding were tested.

The last process of this connection is coding so that Maxsurf runs the analysis. The way is the same as before, which is creating a new button that will be assigned to the new sub-line in Visual Basic. After that the code entered is in the following format:

```
hydromaxApp.Design.ActiveAnalysisMode = hmAMStability
hydromaxApp.Design.RunAnalysis
```

By running the code above, Maxsurf will start to analyze the loadcase that we have input into Maxsurf.

After that coding is done to send commands to Maxsurf to send the desired stability analysis results to Microsoft Excel. To send the command the following code is used.

```
H = 1
For Each laresult In hydromaxApp.Design.LargeAngleStabilityResults
Range("N50").Offset(H, 0).Value = laresult.Heel
Range("o50").Offset(H, 0).Value = laresult.GZ
H = H + 1
Next
```

The code above is the code used to display the results of the stability analysis, which is to display the heel value and the GZ value. Heel value in degree and GZ value in m. then from this value graph is created to find out the GZ curve of the analysis.

The next code is to display the required criteria, as described above. The code is as follows.

```
Nc = hydromaxApp.Design.Criteria.Count
row = 1
For C = 1 To Nc
If (hydromaxApp.Design.Criteria.Item(C).IncludeForAnalysis) Then
Range("D52").Offset(row, 0).Value =
hydromaxApp.Design.Criteria.Item(C).Parameter("CritName")
Range("G52").Offset(row, 0).Value =
hydromaxApp.Design.Criteria.Item(C).Result("RequiredValue")
Range("I52").Offset(row, 0).Value =
hydromaxApp.Design.Criteria.Item(C).Result("ActualValue")
status = hydromaxApp.Design.Criteria.Item(C).status
If (status = hmCSPass) Then Range("K52").Offset(row, 0).Value = "Pass"
```

```
If (status = hmCSFail) Then Range("K52").Offset(row, 0).Value = "Fail"
If (status = hmCSNotAnalysed) Then Range("K452").Offset(row, 0).Value =
"NotAnalysed"
row = row + 1
End If
Next
```

The code above is the code used to display the required criteria. The code above means "if the criteria are included in the analysis, then in cell D52 displayed the criteria name, in cell G52 a required value is displayed, in cell I52 the actual value is displayed" and "if the criterion is fulfilled K52 will be filled with Pass, if it fails then K52 will fill Fail, if not analyzed, K52 will be filled in Not Analyzed”.

3.6. Stability Loadcase for Vehicles Arrangement on Ro-Ro Ship

Making this load case is used to analyze the stability of the ship in each variation of vehicle arrangement. Making the load case is done on two software, Microsoft Excel and Maxsurf. The first load case made on Maxsurf then made the same in Microsoft Excel. After that what variations are determined into the analysis.

Actually, the load case variation used depends on the real conditions that exist when loading the vehicle into the ship. However, in this research the load case variation used is the condition of the vessel with empty load or initial condition, the ship with half load condition, the ship with a three-quarter load condition, the ship with full load condition, the ship with overload condition.

Initial condition is the condition of the ship at no load or the ship is not filled by any vehicle with fully ballast. This condition is used as an ideal state of ship stability, which will later be compared with its stability graph with a loaded vessel.

Ship with a half load condition are ships with a half load of payload, in this case the load used is 2 cars weighing around 3 tons and trucks weighing around 20 tons. The results of the stability chart will be compared with the condition of the ship during the initial condition.

Ships with three-quarter conditions are three-quarter payload vessels. In this case, the load used is 4 trucks and 4 cars. The results of the stability chart will be compared with the condition of the ship during the initial condition.

A ship with a full load condition is a ship that fulfills the entire payload. In this case, it was adjusted to the design of the ship, namely 8 trucks weighing around 20 tons. The results of the stability chart will be compared with the condition of the ship during the initial condition.

A ship with an overload condition is a ship with a heavy load that exceeds the payload. In this case 8 trucks weighing 25 tons were taken from the truck load at the Rafelia 2 ship accident (Komite Nasional Keselamatan Transportasi, 2016). The condition is used as an analysis to determine whether the condition of ship overload can still maintain its stability or not.

3.7. Comparing Output with Rules

After the connection between Microsoft Excel and Maxsurf is done and the stability load case has been inputted from Microsoft Excel to Maxsurf, then the analysis of the stability of the ship can be done. After the analysis results are obtained, the results that displayed in the output section in Microsoft excel are compared with the regulations of the IMO code of Intact Stability. If the results are in accordance with the regulations, the process will continue. If not, process must be repeated from the Connection between Maxsurf and Microsoft Excel.

All data obtained from the analysis will also be displayed in Microsoft Excel by creating a new column with data that needs to be displayed in Microsoft Excel, including:

1. Criteria Name
2. Required Value
3. Actual Value
4. Status
5. GZ curve

The column along with the data that needs to be displayed is as shown in Figure 3.14 below.

Criteria Name	Required Value	Actual Value	Status	GZ curve		
3.1.2.1: Area 0 to 30	3,15			Initial Value		Actual Value
3.1.2.1: Area 0 to 40	5,16			-30	-1,38647	
3.1.2.1: Area 30 to 40	1,72			-20	-1,09302	
3.1.2.2: Max GZ at 30 or greater	0,2			-10	-0,55498	
3.1.2.3: Angle of maximum GZ	25			0	-4,6E-06	
3.1.2.4: Initial GMt	0,15			10	0,554967	
3.1.2.5: Passenger crowding: an	10			20	1,093033	
3.1.2.6: Turn: angle of equilibriu	10			30	1,386402	
				40	1,435014	
				50	1,373118	
				60	1,174717	
				70	0,837802	
				80	0,420558	
				90	-0,0329	
				100	-0,48676	
				110	-0,90576	
				120	-1,24827	
				130	-1,48213	
				140	-1,61429	
				150	-1,63009	
				160	-1,39646	
				170	-0,7291	
				180	4,65E-06	

Figure 3. 14: Table of Compliance Results of Analysis with Rules

From Figure 3.14, there are several columns used to fulfill the rules. The first is the "Criteria Name" which is used to determine what criteria need to be known and fulfilled. Then the second column is "Required Value" which is used to display the values that need to be fulfilled. This value can be in the form of a minimum or maximum value, depending on the rules that govern and are chosen. The third column is used to display the value of the analysis that has been done. The fourth column, which is "Status", is used to display the compliance status of the analysis results with the rules that have been chosen, if the column displays "Pass" then the results of the analysis have met, if it displays "Fail" then it has not fulfilled. The last column is used to display the GZ results in each degree of heel degree the ship after analysis.

All results obtained from the analysis carried out by Maxsurf must be verified by comparing the results displayed in the output with the results found in the Maxsurf software itself. If it is not appropriate, an evaluation of the coding used must be done. If the comparison results are correct, then the software can be used properly.

3.8. Analysis and Conclusions

After all the steps are done, then the next is the conclusion of the analysis and integration between software. It is expected that later the conclusions can answer the problems that become the purpose of this thesis. In addition, advice is needed based on the results of research to improve the final project to be perfect.

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CHAPTER IV

RESULTS AND DISCUSSION

4.1. Introduction

After conducting research based on the research methodology outlined in the previous chapter, it was obtained several results based on the processes that had been carried out. These results are expected to be able to answer the purpose of this study. To that end, all these things will be discussed in this section.

4.2. The Ship Model

The following is the design of the ship that has been modeled as a ship in Maxsurf, as can be seen in Figure 4.1 below. In figure below shows the 3D model of the ship.

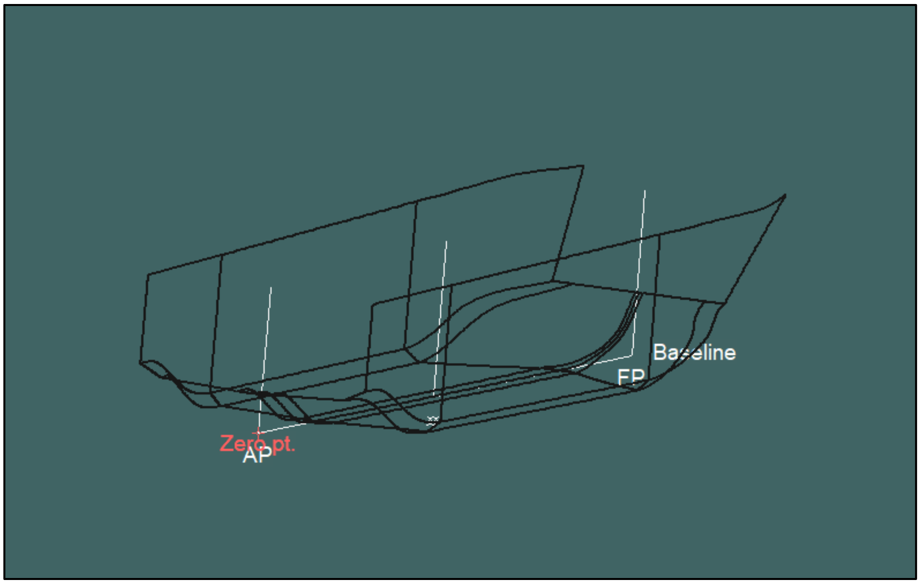


Figure 4. 1: 3D Design of Ship

Also, for front view, side view, and top view can be seen in the following Figure 4.2, Figure 4.3, Figure 4.4. All the ship models is necessary to make the stability analysis more accurate. The more accurate the design, the more accurate the result.

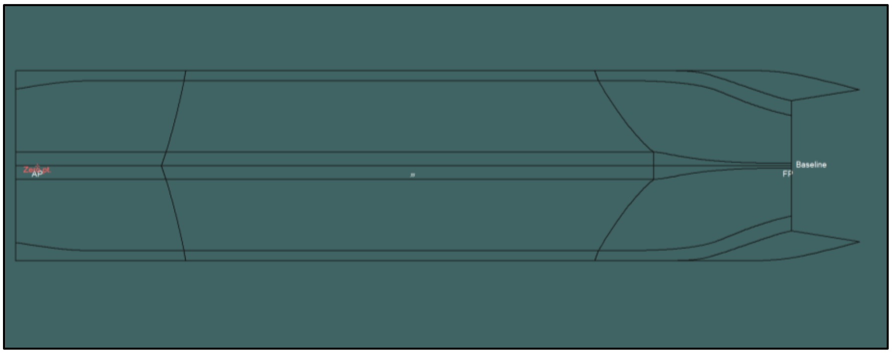


Figure 4. 2: Top View of Ship Design

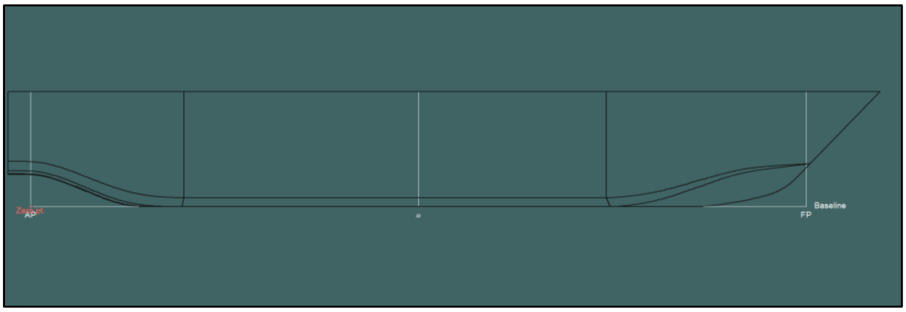


Figure 4. 3: Side View of Ship

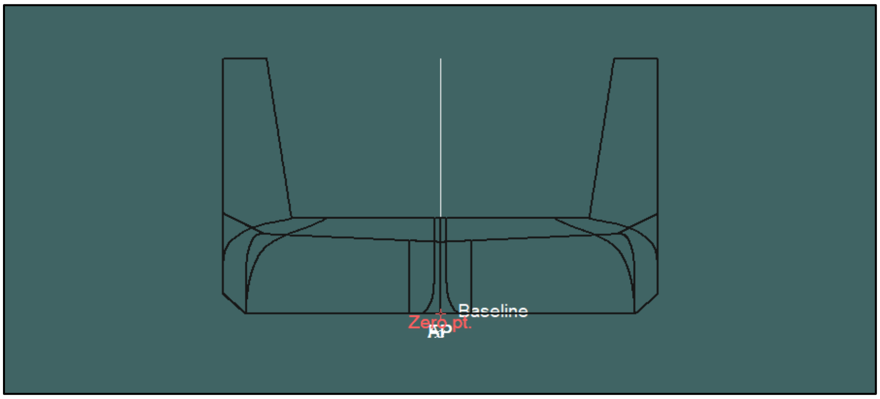


Figure 4. 4: Front View of Ship

In Figure 4.5 the following is also the result of load cases from this ship that have been made in Maxsurf, these load cases is contain all of the load to be loaded by the ship for voyage.

	Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
1	Lightship	1	500,000	500,000			15,550	0,000	2,500	0,000	User Specifie
2	Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000	User Specifie
3	Truck 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
4	Truck 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
5	Truck 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
6	Truck 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
7	Truck 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
8	Truck 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
9	Truck 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
10	Truck 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
11	Car 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
12	Car 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
13	Car 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
14	Car 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
15	Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
16	Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
17	Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
18	Car7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
19	Passanger	112	0,100	11,200			5,700	0,000	5,600	0,000	User Specifie
20	T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	**9,878**	21,000	-1,750	0,392	0,000	Maximum
21	T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	**9,878**	21,000	1,750	0,392	0,000	Maximum
22	T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	**13,171**	16,800	-1,750	0,392	0,000	Maximum
23	T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	**13,171**	16,800	1,750	0,392	0,000	Maximum
24	T.A.T. (C)	100%	22,239	22,239	22,239	**22,239**	3,673	0,000	1,961	0,000	Maximum
25	T.A.B. No.1 (PS)	100%	27,440	27,440	26,771	**26,771**	28,783	-1,745	0,401	0,000	Maximum
26	T.A.B. No.1 (SB)	100%	27,440	27,440	26,771	**26,771**	28,783	1,745	0,401	0,000	Maximum
27	T.A.B. No.2 (PS)	0%	21,442	0,000	20,919	**0,000**	4,752	-1,168	0,242	0,000	Maximum
28	T.A.B. No.2 (SB)	0%	21,442	0,000	20,919	**0,000**	4,752	1,168	0,242	0,000	Maximum
29	T.C.H.	**0%**	42,136	0,000	41,108	0,000	37,842	0,000	0,286	0,000	Maximum
30	T.M.K.	0%	4,057	0,000	4,410	**0,000**	9,004	-0,857	0,000	0,000	Maximum
31	T. Bilga	0%	4,410	0,000	4,410	**0,000**	9,004	0,857	0,000	0,000	Maximum
32	**Total Loadcase**			**628,242**	**214,585**	**121,879**	**16,295**	**0,000**	**2,233**	**0,000**	
33	**FS correction**								**0,000**		
34	**VCG fluid**								**2,233**		

Figure 4. 5: Load cases of Ship

4.3. Maxsurf and Microsoft Excel Connection

The following is the result of the connection between Maxsurf and Microsoft Excel. This result is obtained after coding Visual Basic in Microsoft Excel. All cells in the Microsoft Excel input are connected to Maxsurf. Figure 4.6 is the instruction to use the worksheet.

INSTRUCTIONS

1. Click on Open *Ship Design*, then Maxsurf will open and the design file will open in Maxsurf
2. Determine the vehicle laying area on the ship. Laying area is divided into several sections. The laying of the vehicle can be seen in the boat deck scheme picture. After that, write "Section 1 / Section 2 / Section 3 / Section 4 / Section 5 / Section 6 / Section 7 / Section 8" in the Section column (note the writing of the Section in the cell, if it is wrong then it will not show results) After that click *Section Input*.
3. After that, enter the quantity and weight for each vehicle.
4. After all data has been entered in the input cell, then click *Input Loadcase*
5. After that, click *Start Analysis*

Figure 4. 6: Instructions

Figure 4.7 shows the input interface that have been completely made, also shows the button that will be use as command according the coding that have been written on the VBA.

INPUT

No.	Item Name	Quantity	Unit Mass (Ton)	Total Mass (Ton)	Section	Long. Arm (m)	Trans. Arm (m)	Vert. Arm (m)
1.	Truck 1	1	2000	2000	Section 1	4,45	0	4,7
	Truck 2	1	1400	1400	Section 2	14,15	0	4,7
	Truck 3	1	1500	1500	Section 3	22,65	2,97	4,7
	Truck 4	1	1550	1550	Section 4	22,65	0	4,7
	Truck 5	1	2100	2100	Section 5	22,65	2,97	4,7
	Truck 6	1	0	0	Section 2	14,15	0	4,7
	Truck 7	1	0	0	Section 7	31,15	0	4,7
	Truck 8	1	0	0	Section 8	31,15	2,97	4,7
2.	Car 1	1	1000	1000	Section 6	31,15	2,97	4,7
	Car 2	1	500	500	Section 2	14,15	0	4,7
	Car 3	1	600	600	Section 4	22,65	0	4,7
	Car 4	1	0	0	Section 1	4,45	0	4,7
	Car 5	1	0	0	Section 3	22,65	2,97	4,7
	Car 6	1	0	0	Section 7	31,15	0	4,7
	Car 7	1	0	0	Section 6	31,15	2,97	4,7
	Car 8	1	0	0	Section 5	22,65	2,97	4,7
	Passanger	121	0	0		0	0	0

Open Ship Design

Section input

Input LoadCase

Start Analysis

Figure 4. 7: Input Interface

In Figure 4.8 show the ship deck drawing, the drawing is use as the reference for load to placed on the ship. As shown in the figure there is 8 section for 8 vehicles to loaded on the ship.

Figure 4. 8: Ship Deck Drawing

All complete inputs in Figure 4.7 and Figure 4.8 will be an input unit as shown in Figure 4.9 below.

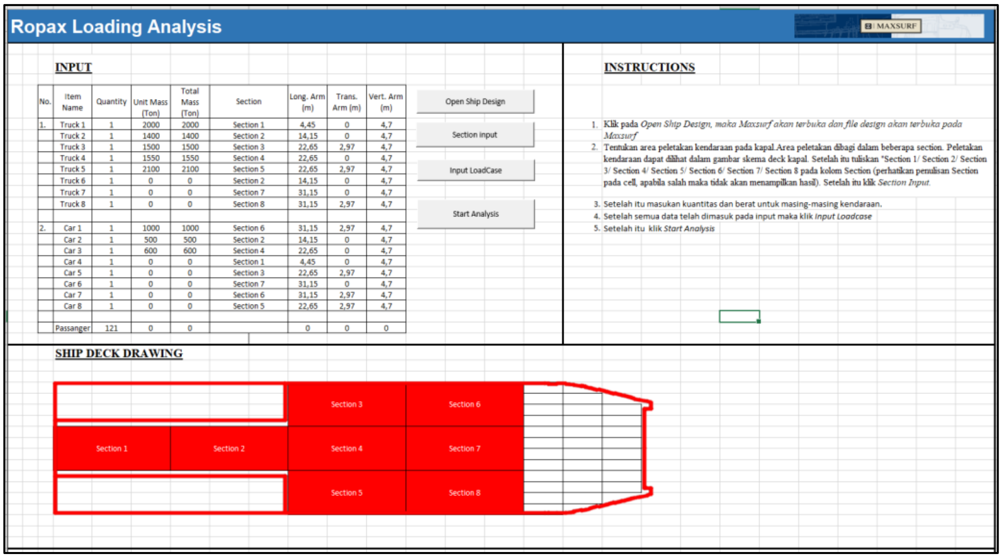


Figure 4. 9: Complete Interface of Input on Microsoft Excel

After creating an interface in Microsoft Excel, the next is the result of the Maxsurf and Microsoft Excel connection. The following are the results of the demonstration from the connection. The initial condition of this design is without load or all load cases are 0, as seen in Figure 4.10 and Figure 4.11 below.

INPUT

No.	Item Name	Quantity	Unit Mass (Ton)	Total Mass (Ton)	Section	Long. Arm (m)	Trans. Arm (m)	Vert. Arm (m)
1.	Truck 1	0	0	0	0	0	0	0
	Truck 2	0	0	0	0	0	0	0
	Truck 3	0	0	0	0	0	0	0
	Truck 4	0	0	0	0	0	0	0
	Truck 5	0	0	0	0	0	0	0
	Truck 6	0	0	0	0	0	0	0
	Truck 7	0	0	0	0	0	0	0
	Truck 8	0	0	0	0	0	0	0
2.	Car 1	0	0	0	0	0	0	0
	Car 2	0	0	0	0	0	0	0
	Car 3	0	0	0	0	0	0	0
	Car 4	0	0	0	0	0	0	0
	Car 5	0	0	0	0	0	0	0
	Car 6	0	0	0	0	0	0	0
	Car 7	0	0	0	0	0	0	0
	Car 8	0	0	0	0	0	0	0
	Passanger	0	0	0	0	0	0	0

Open Ship Design | Section input | Input LoadCase | Start Analysis | Clear All

Figure 4. 10: Initial input conditions in Microsoft Excel

	Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
1	Lightship	1	500,000	500,000			15,550	0,000	2,500	0,000	User Specifie
2	Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000	User Specifie
3	Truck 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
4	Truck 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
5	Truck 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
6	Truck 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
7	Truck 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
8	Truck 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
9	Truck 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
10	Truck 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
11	Car 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
12	Car 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
13	Car 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
14	Car 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
15	Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
16	Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
17	Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
18	Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
19	Passenger	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
20	T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	**9,878**	21,000	-1,750	0,392	0,000	Maximum
21	T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	**9,878**	21,000	1,750	0,392	0,000	Maximum
22	T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	**13,171**	16,800	-1,750	0,392	0,000	Maximum
23	T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	**13,171**	16,800	1,750	0,392	0,000	Maximum
24	T.A.T. (C)	100%	22,239	22,239	22,239	**22,239**	3,673	0,000	1,961	0,000	Maximum
25	T.A.B. No.1 (PS)	100%	27,440	27,440	26,771	**26,771**	28,783	-1,745	0,401	0,000	Maximum
26	T.A.B. No.1 (SB)	100%	27,440	27,440	26,771	**26,771**	28,783	1,745	0,401	0,000	Maximum
27	T.A.B. No.2 (PS)	**98%**	21,442	21,013	20,919	20,500	3,679	-3,453	2,009	0,000	Maximum
28	T.A.B. No.2 (SB)	**98%**	21,442	21,013	20,919	20,500	3,679	3,453	2,009	0,000	Maximum
29	T.C.H.	**98%**	42,136	41,293	41,108	40,286	39,382	0,000	2,271	0,000	Maximum
30	T.M.K.	0%	4,057	0,000	4,410	**0,000**	9,004	-0,857	0,000	0,000	Maximum
31	T. Bilga	0%	4,410	0,000	4,410	**0,000**	9,004	0,857	0,000	0,000	Maximum
32	**Total Loadcase**			**700,361**	**214,585**	**203,166**	**17,068**	**0,000**	**2,168**	**0,000**	
33	**FS correction**								**0,000**		
34	**VCG fluid**								**2,168**		

Figure 4. 11: Initial load case in Maxsurf

It can be seen that all the quantity, weight and section values are 0. After that, all loads, quantities and sections are filled according to the load that loaded to the ship, so that it will be as shown in Figure 4.12 below.

INPUT

No.	Item Name	Quantity	Unit Mass (Ton)	Total Mass (Ton)	Section	Long. Arm (m)	Trans. Arm (m)	Vert. Arm (m)
1.	Truck 1	1	2	2	Section 1	0	0	0
	Truck 2	1	2,2	2,2	Section 3	0	0	0
	Truck 3	1	1,9	1,9	Section 5	0	0	0
	Truck 4	0	0	0	0	0	0	0
	Truck 5	0	0	0	0	0	0	0
	Truck 6	0	0	0	0	0	0	0
	Truck 7	0	0	0	0	0	0	0
	Truck 8	0	0	0	0	0	0	0
2.	Car 1	1	1	1	Section 2	0	0	0
	Car 2	1	1,2	1,2	Section 4	0	0	0
	Car 3	1	0,9	0,9	Section 6	0	0	0
	Car 4	1	1,2	1,2	Section 7	0	0	0
	Car 5	1	1,1	1,1	Section 8	0	0	0
	Car 6	0	0	0	0	0	0	0
	Car 7	0	0	0	0	0	0	0
	Car 8	0	0	0	0	0	0	0
	Passanger	0	0	0	0	0	0	0

Open Ship Design

Section input

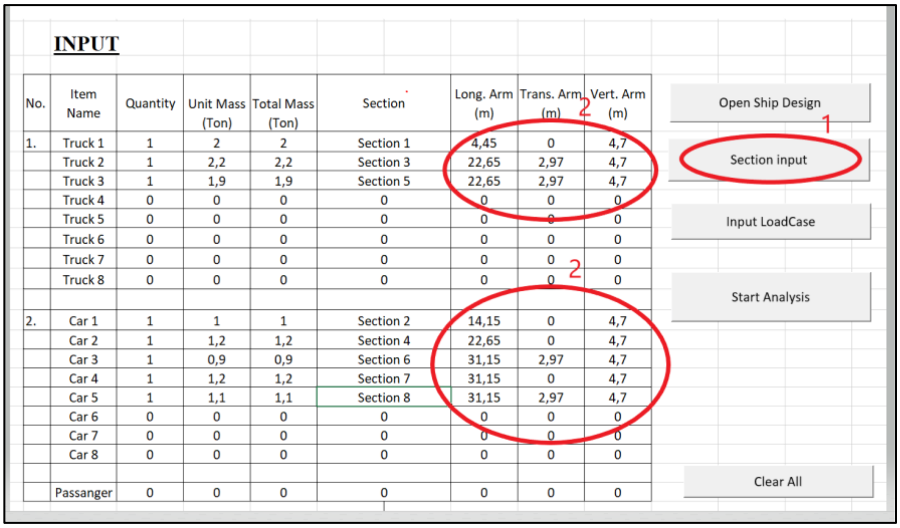
Input LoadCase

Start Analysis

Clear All

Figure 4. 12: Filling input

In Figure 4.13 shown how after the section column has been filled and the section input button have been clicked (no. 1), then the coordinate for vehicle arrangement (no. 2) will be change according to the coding that has been do in Chapter III.

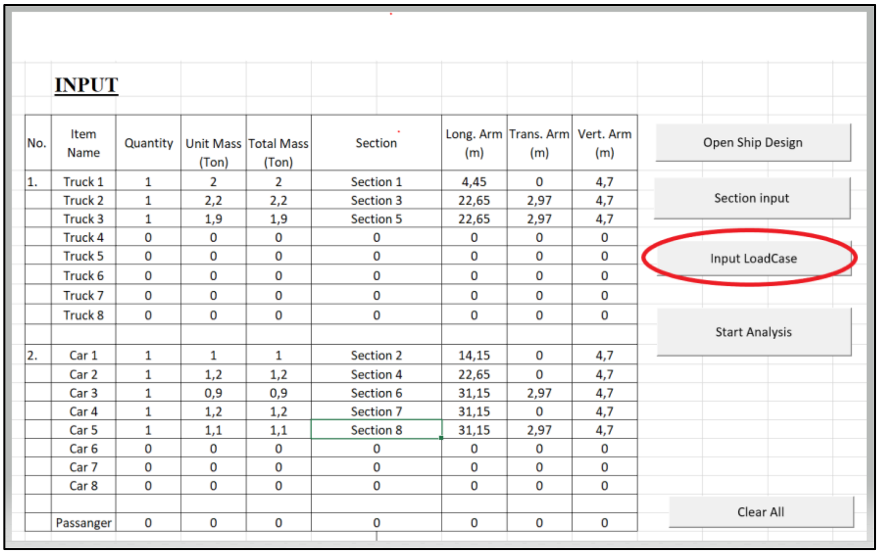


INPUT

No.	Item Name	Quantity	Unit Mass (Ton)	Total Mass (Ton)	Section	Long. Arm (m)	Trans. Arm (m)	Vert. Arm (m)
1.	Truck 1	1	2	2	Section 1	4,45	0	4,7
	Truck 2	1	2,2	2,2	Section 3	22,65	2,97	4,7
	Truck 3	1	1,9	1,9	Section 5	22,65	2,97	4,7
	Truck 4	0	0	0	0	0	0	0
	Truck 5	0	0	0	0	0	0	0
	Truck 6	0	0	0	0	0	0	0
	Truck 7	0	0	0	0	0	0	0
	Truck 8	0	0	0	0	0	0	0
2.	Car 1	1	1	1	Section 2	14,15	0	4,7
	Car 2	1	1,2	1,2	Section 4	22,65	0	4,7
	Car 3	1	0,9	0,9	Section 6	31,15	2,97	4,7
	Car 4	1	1,2	1,2	Section 7	31,15	0	4,7
	Car 5	1	1,1	1,1	Section 8	31,15	2,97	4,7
	Car 6	0	0	0	0	0	0	0
	Car 7	0	0	0	0	0	0	0
	Car 8	0	0	0	0	0	0	0
	Passanger	0	0	0	0	0	0	0

Figure 4. 13: Condition after the button "Section input " is clicked

Then click the Input load analysis button, the data that have been filled in input section will be send to Maxsurf load case. So that the load case on Maxsurf changes according to what is in Microsoft Excel, as shown in following Figure 4.15.



INPUT

No.	Item Name	Quantity	Unit Mass (Ton)	Total Mass (Ton)	Section	Long. Arm (m)	Trans. Arm (m)	Vert. Arm (m)
1.	Truck 1	1	2	2	Section 1	4,45	0	4,7
	Truck 2	1	2,2	2,2	Section 3	22,65	2,97	4,7
	Truck 3	1	1,9	1,9	Section 5	22,65	2,97	4,7
	Truck 4	0	0	0	0	0	0	0
	Truck 5	0	0	0	0	0	0	0
	Truck 6	0	0	0	0	0	0	0
	Truck 7	0	0	0	0	0	0	0
	Truck 8	0	0	0	0	0	0	0
2.	Car 1	1	1	1	Section 2	14,15	0	4,7
	Car 2	1	1,2	1,2	Section 4	22,65	0	4,7
	Car 3	1	0,9	0,9	Section 6	31,15	2,97	4,7
	Car 4	1	1,2	1,2	Section 7	31,15	0	4,7
	Car 5	1	1,1	1,1	Section 8	31,15	2,97	4,7
	Car 6	0	0	0	0	0	0	0
	Car 7	0	0	0	0	0	0	0
	Car 8	0	0	0	0	0	0	0
	Passanger	0	0	0	0	0	0	0

Figure 4. 14: Input Loadcase Button

	Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
1	Lightship	1	500,000	500,000			15,550	0,000	2,500	0,000	User Specifie
2	Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000	User Specifie
3	Truck 1	1	2,000	2,000			4,450	0,000	4,700	0,000	User Specifie
4	Truck 2	1	2,200	2,200			22,650	2,970	4,700	0,000	User Specifie
5	Truck 3	1	1,900	1,900			22,650	2,970	4,700	0,000	User Specifie
6	Truck 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
7	Truck 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
8	Truck 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
9	Truck 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
10	Truck 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
11	Car 1	1	1,000	1,000			14,150	0,000	4,700	0,000	User Specifie
12	Car 2	1	1,200	1,200			22,650	0,000	4,700	0,000	User Specifie
13	Car 3	1	0,900	0,900			31,150	2,970	4,700	0,000	User Specifie
14	Car 4	1	1,200	1,200			31,150	0,000	4,700	0,000	User Specifie
15	Car 5	1	1,100	1,100			31,150	2,970	4,700	0,000	User Specifie
16	Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
17	Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
18	Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
19	Passenger	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
20	T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	**9,878**	21,000	-1,750	0,392	0,000	Maximum
21	T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	**9,878**	21,000	1,750	0,392	0,000	Maximum
22	T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	**13,171**	16,800	-1,750	0,392	0,000	Maximum
23	T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	**13,171**	16,800	1,750	0,392	0,000	Maximum
24	T.A.T. (C)	100%	22,239	22,239	22,239	**22,239**	3,673	0,000	1,961	0,000	Maximum
25	T.A.B. No.1 (PS)	100%	27,440	27,440	26,771	**26,771**	28,783	-1,745	0,401	0,000	Maximum
26	T.A.B. No.1 (SB)	100%	27,440	27,440	26,771	**26,771**	28,783	1,745	0,401	0,000	Maximum
27	T.A.B. No.2 (PS)	**98%**	21,442	21,013	20,919	20,500	3,679	-3,453	2,009	0,000	Maximum
28	T.A.B. No.2 (SB)	**98%**	21,442	21,013	20,919	20,500	3,679	3,453	2,009	0,000	Maximum
29	T.C.H.	**98%**	42,136	41,293	41,108	40,286	39,382	0,000	2,271	0,000	Maximum
30	T.M.K.	0%	4,057	0,000	4,410	**0,000**	9,004	-0,857	0,000	0,000	Maximum
31	T. Bilga	0%	4,410	0,000	4,410	**0,000**	9,004	0,857	0,000	0,000	Maximum
32	**Total Loadcase**			**711,861**	**214,585**	**203,166**	**17,134**	**0,025**	**2,209**	**0,000**	
33	**FS correction**								**0,000**		
34	**VCG fluid**								**2,209**		

INPUT

No.	Item Name	Quantity	Unit Mass (kg)	Total Mass (Ton)	Section	Long. Arm (m)	Trans. Arm (m)	Vert. Arm (m)
1.	Truck 1	1	2000	2000	Section 1	4,45	0	4,7
	Truck 2	1	2200	2200	Section 3	22,65	2,97	4,7
	Truck 3	1	1900	1900	Section 5	22,65	2,97	4,7
	Truck 4	0	0	0	0	0	0	0
	Truck 5	0	0	0	0	0	0	0
	Truck 6	0	0	0	0	0	0	0
	Truck 7	0	0	0	0	0	0	0
	Truck 8	0	0	0	0	0	0	0
2.	Car 1	1	1000	1000	Section 2	14,15	0	4,7
	Car 2	1	1200	1200	Section 4	22,65	0	4,7
	Car 3	1	900	900	Section 6	31,15	2,97	4,7
	Car 4	1	1200	1200	Section 7	31,15	0	4,7
	Car 5	1	1100	1100	Section 8	31,15	2,97	4,7
	Car 6	0	0	0	0	0	0	0
	Car 7	0	0	0	0	0	0	0
	Car 8	0	0	0	0	0	0	0
	Passanger	0	0	0	0	0	0	0

Open Ship Design

Section input

Input LoadCase

Start Analysis

Clear All

Figure 4. 15: Load case on Maxsurf have changed, just like in Microsoft Excel

Another result of this connection is that Microsoft Excel can also order Maxsurf to analyze the load case that was entered earlier. If we check "Start Analysis", then Maxsurf will immediately start analysis. After that the result of the stability analysis can be discussed.

4.4. Stability Profile

After successfully connecting Microsoft Excel and Maxsurf, analysis of stability from each load case can be done. Actually, after the connection process is complete, the load cases can be input according to the conditions in the field. But in this study the load cases included are load cases on empty loads (no load), load cases on half loads, three-quarters payloads, full load, and overload condition. Load cases also use a variety of weight of car and truck. All the complete results from the analysis carried out by Maxsurf can be seen in appendix 2 and the results of the analysis are as follows.

4.4.1. Initial Condition Load Case

Figure 4.16 below is a load case for vessels with no load, where ships with no load is vessels that are when trucks and cars are not loaded to vessel and have only a full ballast. Ships with no load conditions like this will be used as a comparison with other ship conditions, such as the condition of the ship in a half load, three quarters of the load, full load, overload condition. The following is the result of analysis of the vessel with an empty load condition.

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	500,000	500,000			18,610	0,000	3,750	0,000	User Specified
Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000	User Specified
Truck 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Truck 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Truck 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Truck 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Truck 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Truck 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Truck 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Truck 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Passenger	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	9,878	21,000	-1,750	0,392	0,000	Maximum
T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	9,878	21,000	1,750	0,392	0,000	Maximum
T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	13,171	16,800	-1,750	0,392	0,000	Maximum
T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	13,171	16,800	1,750	0,392	0,000	Maximum
T.A.T. (C)	100%	22,239	22,239	22,239	22,239	3,673	0,000	1,961	0,000	Maximum
T.A.B. No.1 (PS)	100%	27,440	27,440	26,771	26,771	28,783	-1,745	0,401	0,000	Maximum
T.A.B. No.1 (SB)	100%	27,440	27,440	26,771	26,771	28,783	1,745	0,401	0,000	Maximum
T.A.B. No.2 (PS)	100%	21,442	21,442	20,919	20,919	3,678	-3,454	2,034	0,000	Maximum
T.A.B. No.2 (SB)	100%	21,442	21,442	20,919	20,919	3,678	3,454	2,034	0,000	Maximum
T.C.H.	10%	42,136	4,214	41,108	4,111	38,678	0,000	1,152	227,901	Maximum
T.M.K.	1%	4,057	0,041	4,410	0,044	9,000	-0,875	0,004	1,479	Maximum
T. Bilga	1%	4,410	0,044	4,410	0,044	9,000	0,875	0,004	1,608	Maximum
Total Loadcase			664,224	214,585	167,916	18,103	0,000	3,098	230,988	
FS correction								0,348		
VCG fluid								3,445		

Figure 4. 16: Initial condition load case

Interval of initial stability of the ship with initial condition load case is at 0^o - 90^o. At this interval it can be seen that the ship still has a positive GZ value to a heel angle of 90^o. From Figure 4.17 it can also be seen that maximum GZ is 1.4 m at a heel angle of around 40°, after that the ship righting lever will decrease drastically and lose its turning moment, so until around 90° the ship will start to capsize.

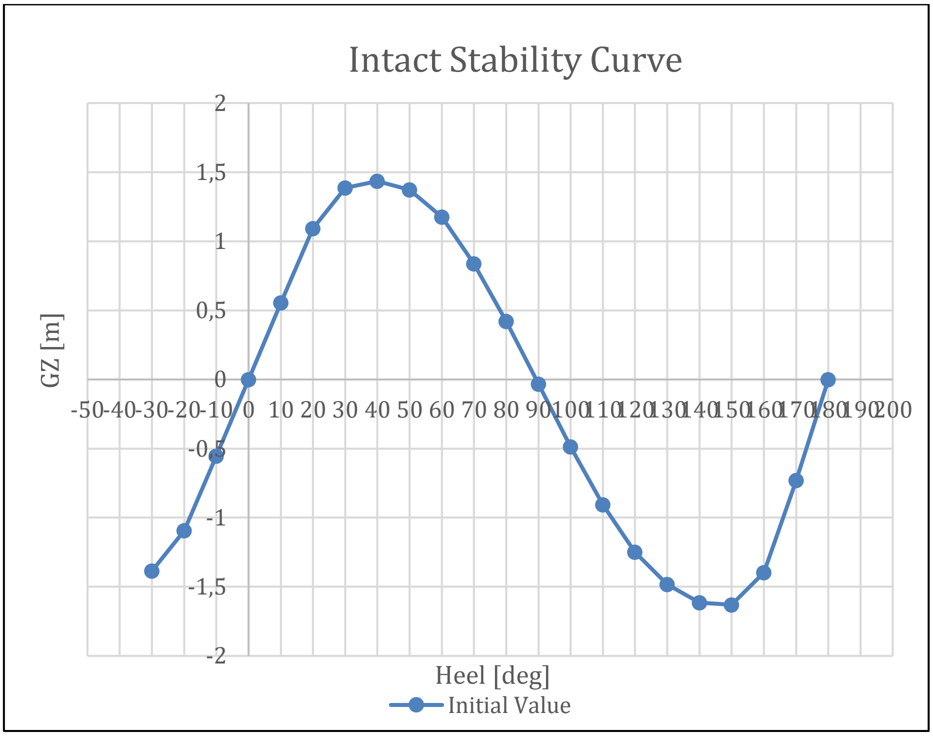


Figure 4. 17: GZ curve of initial condition

4.4.2. Half Load Case

The next situation is on the condition of the ship which has a half load. This condition occurs when the load on the ship is filled halfway on the deck of the vehicle placement area, with 2 trucks and 2 cars, as illustrated in following Figure 4.18. As well as the results of calculating ship stability, see Figure 4.19 below.

In Figure 4.19, it can be seen that the initial stability interval for the condition of the half cargo vessel is around 0° - 76°. at that interval the ship still has a positive GZ up to a heel angle of 76°. But the ship maximum GZ is 1.1 m at around 30°, if it exceeds the that angle the ship righting lever will decreased drastically and will lose its turning moment, until around 76° the ship will capsize.

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m
Lightship	1	500,000	500,000			18,610	0,000	3,750	0,000
Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000
Truck 1	1	20,000	20,000			22,650	0,000	4,700	0,000
Truck 2	1	19,500	19,500			31,150	0,000	4,700	0,000
Truck 3	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 4	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 1	1	3,000	3,000			22,650	-2,970	4,700	0,000
Car 2	1	2,500	2,500			22,650	2,970	4,700	0,000
Car 3	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 4	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Passenger	60	0,100	6,000			5,700	0,000	5,600	0,000
T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	9,878	21,000	-1,750	0,392	0,000
T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	9,878	21,000	1,750	0,392	0,000
T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	13,171	16,800	-1,750	0,392	0,000
T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	13,171	16,800	1,750	0,392	0,000
T.A.T. (C)	100%	22,239	22,239	22,239	22,239	3,673	0,000	1,961	0,000
T.A.B. No.1 (PS)	1%	27,440	0,274	26,771	0,268	28,540	-1,682	0,004	35,157
T.A.B. No.1 (SB)	1%	27,440	0,274	26,771	0,268	28,540	1,682	0,004	35,157
T.A.B. No.2 (PS)	1%	21,442	0,214	20,919	0,209	4,570	-2,921	0,430	8,789
T.A.B. No.2 (SB)	1%	21,442	0,214	20,919	0,209	4,570	2,921	0,430	8,789
T.C.H.	1%	42,136	0,421	41,108	0,411	38,338	0,000	0,606	227,901
T.M.K.	1%	4,057	0,041	4,410	0,044	9,000	-0,875	0,004	1,479
T. Bilga	1%	4,410	0,044	4,410	0,044	9,000	0,875	0,004	1,608
Total Loadcase			614,645	214,585	69,790	18,510	-0,002	3,561	318,882
FS correction								0,519	
VCG fluid								4,080	

Figure 4. 18: Load case of half load condition

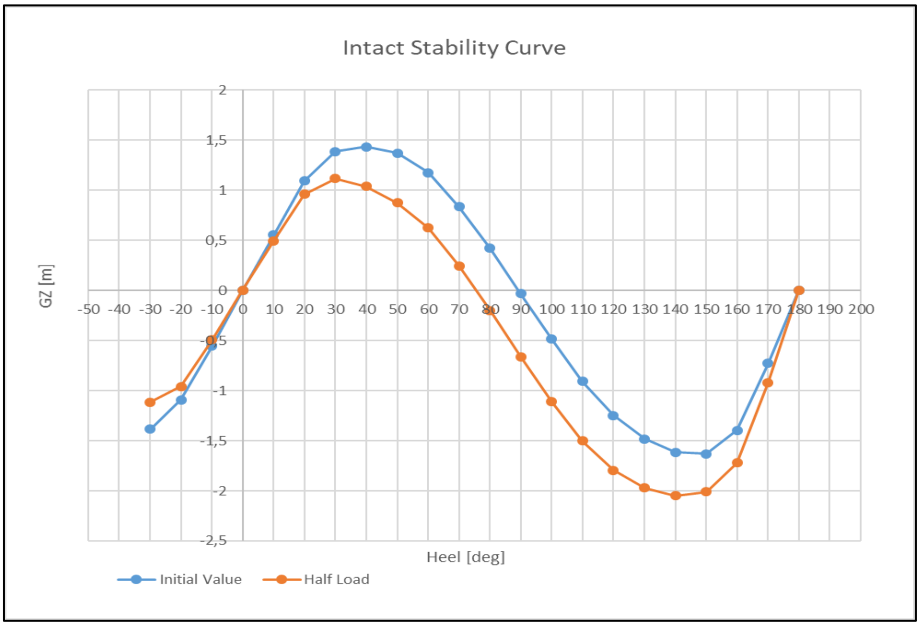


Figure 4. 19: GZ curve of half load condition

4.4.3. Three-Quarters Load Case

The next load case for the ship load is a three-quarters loaded. The load for the condition is four trucks and four cars, with different weight conditions, as can be seen in the following Figure 4.20.

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m
Lightship	1	500,000	500,000			18,610	0,000	3,750	0,000
Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000
Truck 1	1	20,000	20,000			31,150	0,000	4,700	0,000
Truck 2	1	21,000	21,000			22,650	0,000	4,700	0,000
Truck 3	1	20,500	20,500			4,450	0,000	4,470	0,000
Truck 4	1	20,000	20,000			14,150	0,000	4,700	0,000
Truck 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 1	1	3,000	3,000			22,650	-2,970	4,700	0,000
Car 2	1	2,500	2,500			22,650	2,970	4,700	0,000
Car 3	1	3,000	3,000			31,150	-2,970	4,700	0,000
Car 4	1	2,500	2,500			31,150	2,970	4,700	0,000
Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Passenger	60	0,100	6,000			5,700	0,000	5,600	0,000
T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	9,878	21,000	-1,750	0,392	0,000
T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	9,878	21,000	1,750	0,392	0,000
T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	13,171	16,800	-1,750	0,392	0,000
T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	13,171	16,800	1,750	0,392	0,000
T.A.T. (C)	100%	22,239	22,239	22,239	22,239	3,673	0,000	1,961	0,000
T.A.B. No.1 (PS)	1%	27,440	0,274	26,771	0,268	28,540	-1,682	0,004	35,157
T.A.B. No.1 (SB)	1%	27,440	0,274	26,771	0,268	28,540	1,682	0,004	35,157
T.A.B. No.2 (PS)	1%	21,442	0,214	20,919	0,209	4,570	-2,921	0,430	8,789
T.A.B. No.2 (SB)	1%	21,442	0,214	20,919	0,209	4,570	2,921	0,430	8,789
T.C.H.	1%	42,136	0,421	41,108	0,411	38,338	0,000	0,606	227,901
T.M.K.	1%	4,057	0,041	4,410	0,044	9,000	-0,875	0,004	1,479
T. Bilga	1%	4,410	0,044	4,410	0,044	9,000	0,875	0,004	1,608
Total Loadcase			662,145	214,585	69,790	18,064	-0,004	3,636	318,882
FS correction								0,482	
VCG fluid								4,117	

Figure 4. 20: Three-quarter load case condition

In Figure 4.21, it can be seen that the initial stability interval for the condition of the ship with three-quarter load condition is around 0^o - 74^o. At that interval the ship still has a positive GZ up to a heel angle of around 74^o. But the ship is only maximum righting lever (GZ) is 1.05 m in around 30^o, if it exceeds that angle the ship GZ will drastically decreased and will lose its turning moment, until around 74^o the ship will be hardly back to upright position and will capsized.

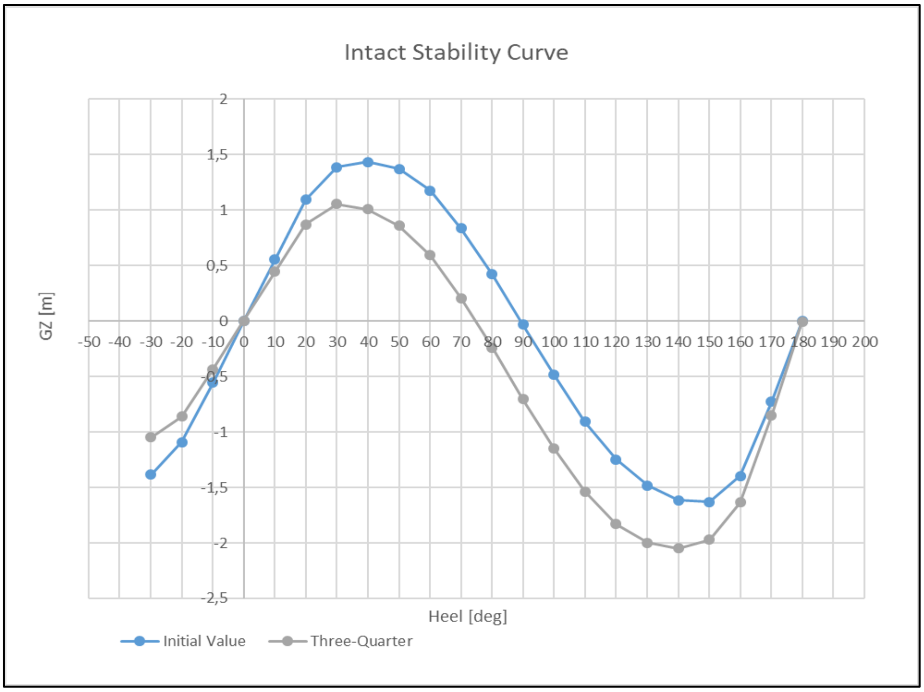


Figure 4. 21: GZ curve of three-quarter load condition

4.4.4. Full Load Case

The next condition is the condition where the ship in fully loaded. The load of the ship is taken from its maximum payload, that is eight trucks with 20 tons each. To make the situation more realistic, the weight is variated at around 20 tons. The load can be seen in the following Figure 4.2.

After the analysis is done, the stability curve can be seen on the following Figure 4.23. From the curve we can see that the initial stability interval for the condition of the fully loaded ship is around 0º - 73º. At that interval the ship still has a positive GZ up to a heel angle of 73º. But the ship maximum GZ is 0.97 m at around 30º, if it exceeds that heel angle the ship righting lever will decreased drastically and will lose its turning moment, until around 73º the ship will capsize.

	Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
1	Lightship	1	500,000	500,000			18,610	0,000	3,750	0,000	User Specifie
2	Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000	User Specifie
3	Truck 1	1	20,000	20,000			4,450	0,000	4,700	0,000	User Specifie
4	Truck 2	1	21,000	21,000			14,150	0,000	4,700	0,000	User Specifie
5	Truck 3	1	19,000	19,000			22,650	-2,970	4,700	0,000	User Specifie
6	Truck 4	1	20,500	20,500			22,650	0,000	4,700	0,000	User Specifie
7	Truck 5	1	19,500	19,500			22,650	2,970	4,700	0,000	User Specifie
8	Truck 6	1	20,000	20,000			31,150	-2,970	4,700	0,000	User Specifie
9	Truck 7	1	21,500	21,500			31,150	0,000	4,700	0,000	User Specifie
10	Truck 8	1	19,500	19,500			31,150	2,970	4,700	0,000	User Specifie
11	Car 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
12	Car 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
13	Car 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
14	Car 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
15	Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
16	Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
17	Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
18	Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specifie
19	Passenger	112	0,100	11,200			5,700	0,000	5,600	0,000	User Specifie
20	T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	**9,878**	21,000	-1,750	0,392	0,000	Maximum
21	T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	**9,878**	21,000	1,750	0,392	0,000	Maximum
22	T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	**13,171**	16,800	-1,750	0,392	0,000	Maximum
23	T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	**13,171**	16,800	1,750	0,392	0,000	Maximum
24	T.A.T. (C)	100%	22,239	22,239	22,239	**22,239**	3,673	0,000	1,961	0,000	Maximum
25	T.A.B. No.1 (PS)	**1%**	27,440	0,274	26,771	0,268	28,540	-1,682	0,004	35,157	Maximum
26	T.A.B. No.1 (SB)	**1%**	27,440	0,274	26,771	0,268	28,540	1,682	0,004	35,157	Maximum
27	T.A.B. No.2 (PS)	**1%**	21,442	0,214	20,919	0,209	4,570	-2,921	0,430	8,789	Maximum
28	T.A.B. No.2 (SB)	**1%**	21,442	0,214	20,919	0,209	4,570	2,921	0,430	8,789	Maximum
29	T.C.H.	**1%**	42,136	0,421	41,108	0,411	38,338	0,000	0,606	227,901	Maximum
30	T.M.K.	**1%**	4,057	0,041	4,410	0,044	9,000	-0,875	0,004	1,479	Maximum
31	T. Bilga	**1%**	4,410	0,044	4,410	0,044	9,000	0,875	0,004	1,608	Maximum
32	**Total Loadcase**			**735,845**	**214,585**	**69,790**	**18,814**	**0,000**	**3,755**	**318,882**	
33	**FS correction**								**0,433**		
34	**VCG fluid**								**4,189**		

Figure 4. 22: Fully loaded Load Case Condition

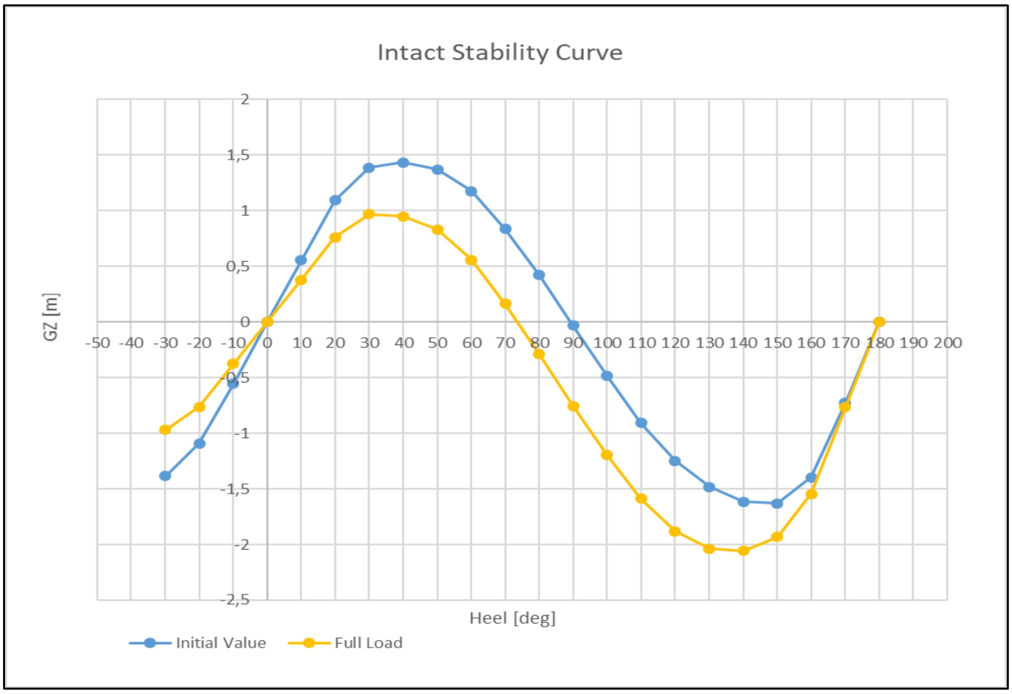


Figure 4. 23: GZ curve of Full Load condition

4.4.5. Overload Load Case

The last condition is the condition where the ship is at overloaded condition. For this condition the load that taken is about 26 tons each truck. The condition is taken from the ship incident that occur because of overload condition *(Komite Nasional Keselamatan Transportasi, 2016)*. The load case of the ship can be seen in following Figure 4.24.

After the analysis is done, the stability curve can be seen on the following Figure 4.25. From the curve we can see that the initial stability interval for the condition of the overloaded condition of ship is around 0^{o} - 71^{o}. At that interval the ship still has a positive GZ up to a heel angle of 71^{o}. But the ship maximum GZ is 0.92 m at around 30^{o}, if it exceeds that heel angle the ship righting lever will drastically decreased and will lose its turning moment, until around 71^{o} the ship will capsized. The condition of this ship is also still safe to sail because of compliance with the rules (IMO Intact Stability rules), as seen in figure 4.26.

Figure 4. 24: Overload Load Case Condition

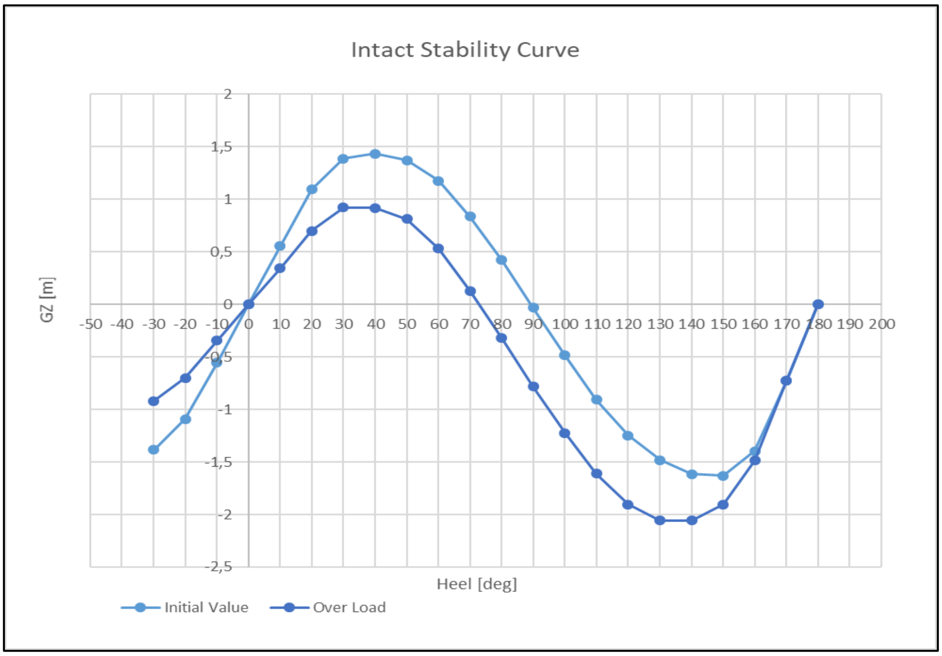


Figure 4. 25:GZ Curve of Overload Condition

Criteria Name	Required Value	Actual Value	Status
3.1.2.1: Area 0 to 30	3,15	15,17	Pass
3.1.2.1: Area 0 to 40	5,16	24,56	Pass
3.1.2.1: Area 30 to 40	1,72	9,39	Pass
3.1.2.2: Max GZ at 30 or greate	0,2	0,00	Pass
3.1.2.3: Angle of maximum GZ	25	34,5	Pass
3.1.2.4: Initial GMt	0,15	1,96	Pass
3.1.2.5: Passenger crowding: a	10	0,2	Pass
3.1.2.6: Turn: angle of equilibriu	10	1,0	Pass

Figure 4. 26: Compliance of overloaded condition to IMO Intact Stability rule

4.4.6. Stability Comparation

All results of the analysis that have been obtained are then compared with each other and from these comparisons a conclusion can be drawn regarding the stability of the ship. The following Figure 4.26 is a comparison of the GZ curve from all stability analysis.

It can be seen from the graph that there is a GZ difference in each load case variation. The difference is that for each added load on the ship, there will be a decrease in the value of the GZ. The decrease in GZ is in accordance with what was stated by Hardjanto (2010), George, La Dage, & Van, (2010), which stated that the moment of static stability is multiplication between displacement and GZ, where when the charge increases, the displacement will rise, and if it rises, the GZ curve will go down because it is directly proportional to the displacement.

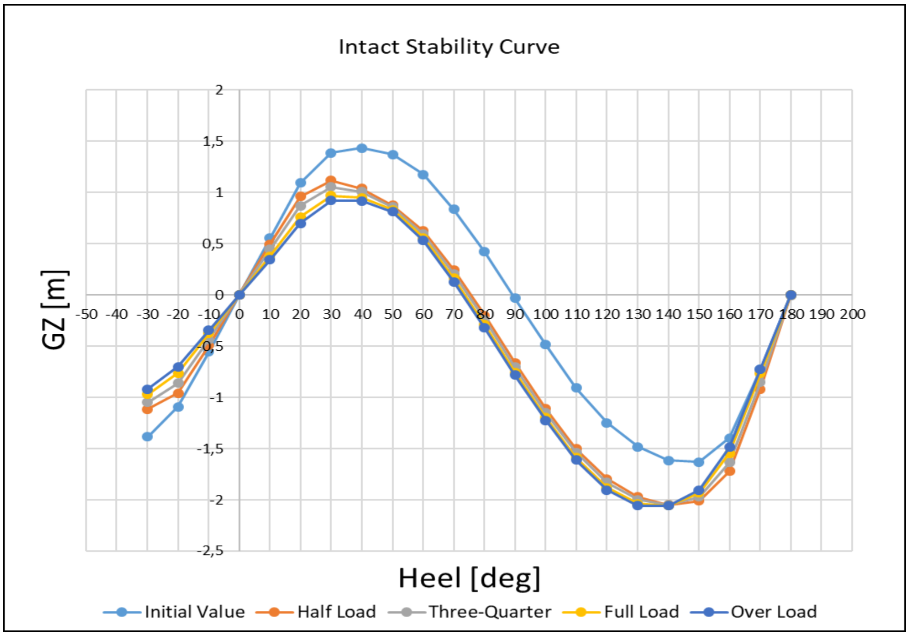
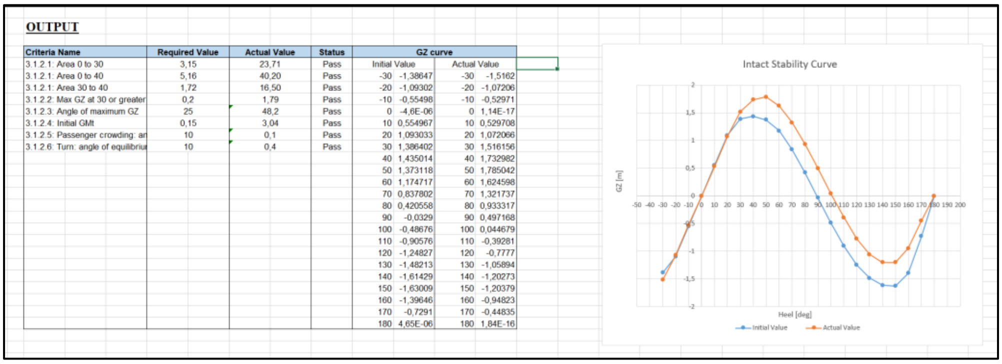


Figure 4. 27: GZ Curve from All Stability Analysis

4.5. Compliance of The Stability Analysis Output to IMO Rules

The results of the analysis that have been done before will be displayed in the output section in Microsoft Excel. But it is necessary to know whether the software output is the same output in Maxsurf in accordance with the rules, in this case the IMO A.749 Code of Intact Stability is used.

After coding as explained in Chapter III, this worksheet in Microsoft Excel is able to display the results of compliance rules from ship analysis. These results can be seen in Figure 4.26 below.



OUTPUT

Criteria Name	Required Value	Actual Value	Status	GZ curve			
				Initial Value		Actual Value	
3.1.2.1: Area 0 to 30	3,15	23,71	Pass	-30	-1,38647	-30	-1,5162
3.1.2.1: Area 0 to 40	5,16	40,20	Pass	-20	-1,09302	-20	-1,07206
3.1.2.1: Area 30 to 40	1,72	16,50	Pass	-10	-0,55498	-10	-0,52971
3.1.2.2: Max GZ at 30 or greater	0,2	1,79	Pass	0	-4,6E-06	0	1,14E-17
3.1.2.3: Angle of maximum GZ	25	48,2	Pass	10	0,554967	10	0,529708
3.1.2.4: Initial GMt	0,15	3,04	Pass	20	1,093033	20	1,072066
3.1.2.5: Passenger crowding: an	10	0,1	Pass	30	1,386402	30	1,516156
3.1.2.6: Turn: angle of equilibriu	10	0,4	Pass	40	1,435014	40	1,732982
				50	1,373118	50	1,785042
				60	1,174717	60	1,624598
				70	0,837802	70	1,321737
				80	0,420558	80	0,933317
				90	-0,0329	90	0,497168
				100	-0,48676	100	0,044679
				110	-0,90576	110	-0,39281
				120	-1,24827	120	-0,7777
				130	-1,48213	130	-1,05894
				140	-1,61429	140	-1,20273
				150	-1,63009	150	-1,20379
				160	-1,39646	160	-0,94823
				170	-0,7291	170	-0,44835
				180	4,65E-06	180	1,84E-16

Figure 4. 28: Rules Compliance in Output of the Analysis

The output results are compared with the output analysis that is in Maxsurf, this is done so that the analysis results displayed are correct. The results of compliance rules on Maxsurf can be seen in Figure 2.7 below.

Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30	3,1513	m.deg	23,7546	Pass	+653,80
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40	5,1566	m.deg	40,1663	Pass	+678,93
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40	1,7189	m.deg	16,4117	Pass	+854,78
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater	0,200	m	1,790	Pass	+795,00
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ	25,0	deg	48,2	Pass	+92,73
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt	0,150	m	3,037	Pass	+1924,67
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.5: Passenger crowding: angle of equilibrium	10,0	deg	0,1	Pass	+98,95
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.6: Turn: angle of equilibrium	10,0	deg	0,4	Pass	+96,34

Figure 4. 29: Rules Compliance on Maxsurf

After the comparison process is complete and the results on the output displayed are correct, then this software is in accordance with its purpose.

CHAPTER V

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

After the research has been carried out and all the results are explained, various of things can be concluded in answering the questions that have been announced. The following are the conclusions.

1. Connecting Microsoft Excel with Maxsurf Stability has been done successfully by recording VBA in Microsoft Excel itself, where Microsoft Excel can be used as input and display output, Maxsurf as software that processes input. So that the stability can be done using the package, and the problems that have been declared fulfilled
2. VBA is used as a place for coding to connect Microsoft Excel and Maxsurf. The code in VBA is obtained from the example in Maxsurf itself
3. The package has been successfully doing the stability analysis and fulfilled the problem that have been declared, there are several conditions with variations of weight and vehicle that are used
4. The first condition is the vessel with no load or initial condition. The ship still has a positive GZ value to a heel angle of 90^o. The maximum GZ is 1.4 m at a heel angle of around 40^o, after that the ship will slowly lose its turning moment, so until around 75^o the ship will start to flip over.
5. The second condition is vessel with half load. This condition occurs when the load on the ship is filled halfway on the deck of the vehicle placement area, with 2 trucks and 2 cars. The ship still has a positive GZ up to a heel angle of 76^o. But the ship maximum GZ is 1.1 m at around 30^o, if it exceeds the that angle the ship righting lever will decreased drastically and will lose its turning moment, until around 76^o the ship will capsize.
6. The third condition is where vessel have third-quarter load. The load for the condition is four trucks and four cars. ship still has a positive GZ up to a heel angle of 74^o. But the ship is only maximum righting lever (GZ) is 1.05 m in around 30^o, if it exceeds that angle the ship GZ will drastically decreased and will lose its turning moment, until around 74^o the ship will be hardly back to upright position and will capsized.
7. The fourth condition is where vessel have fully loaded load. The load of the ship is taken from its maximum payload, that is eight trucks with 20 tons each. ship still has a positive GZ up to a sloping angle of 73^o. But the ship maximum GZ is 0.97 m at around 30^o, if it exceeds that heel angle the ship righting lever will decreased drastically and will lose its turning moment, until around 73^o the ship will capsize.
8. Last condition is when the ship is loaded with overload load. For this condition the load that taken is about 26 tons each truck the ship still has a positive GZ up to a heel angle of 71^o. But the ship maximum GZ is 0.92

m at around 30^o, if it exceeds that heel angle the ship righting lever will drastically decreased and will lose its turning moment, until around 71^o the ship will capsized.

9. All results of the analysis that have been obtained are then compared with each other and can be seen from that there is a GZ difference in each load case variation. The difference is that for each added load on the ship, there will be a decrease in the value of the GZ.
10. The output used to display the results of compliance rules is good to use, this is proven by matching the results of the compliance rules on Maxsurf.

5.2. Recommendation

In working for this research, there is also so much that can be developed from this program, because this program is still in the early development, so there is more space or variation that can make this program better, including are the following.

1. In the input that is in Microsoft Excel it might be possible to add an input to change the ballast of the load case. This is needed to add variety to the analysis and it is also necessary to add a function to set the criteria of the rules used, because to change the criteria and rules used still have to change from Maxsurf itself.
2. There should be more variations of vehicles added, such as motorbikes, small trucks, etc.
3. There should be additional information on output in Microsoft Excel such as ship draft information, heel of the ship after being load, weight distribution, etc. So that more information is displayed to the user.
4. Optimization of automation in Microsoft Excel, so that fewer buttons are used to command the program. This is intended to make the user experience better and easier.
5. There should be more type of analysis that can be analyzed, such as hydrostatic, ship construction, resistance, etc. So that the user get more accurate information about the ship. To do that the worksheet in Microsoft Excel should be connected to another Maxsurf product, such as Modeller and Resistance.
6. Additions to the size of the ship that can be analyzed for stability. This is because in this thesis the writer only uses one type of ship, whereas in fact the ships used are very numerous and the characters vary.

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APPENDIX

Appendix 1 Research Timeline

The following is the timeline of the research that will be conducted.

No	Activities	MONTH 1				MONTH 2				MONTH 3				MONTH 4			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	Problem Identification																
2	Literature Review																
3	Ship Data Collection																
4	Ship Modeling on Maxsurf																
5	Connection between Maxsurf and Microsoft Excel																
6	Stability Loadcase for Vehicles Arrangement on Ro-Ro Ship																
7	Analysis and Conclusions																

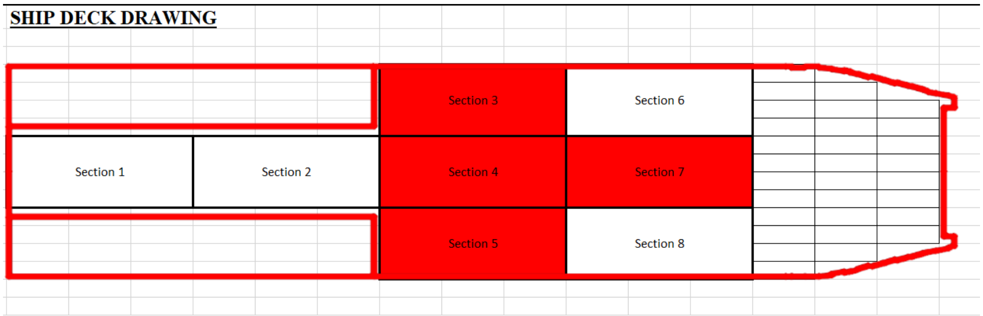
Appendix 2 Stability Result from Maxsurf Analysis

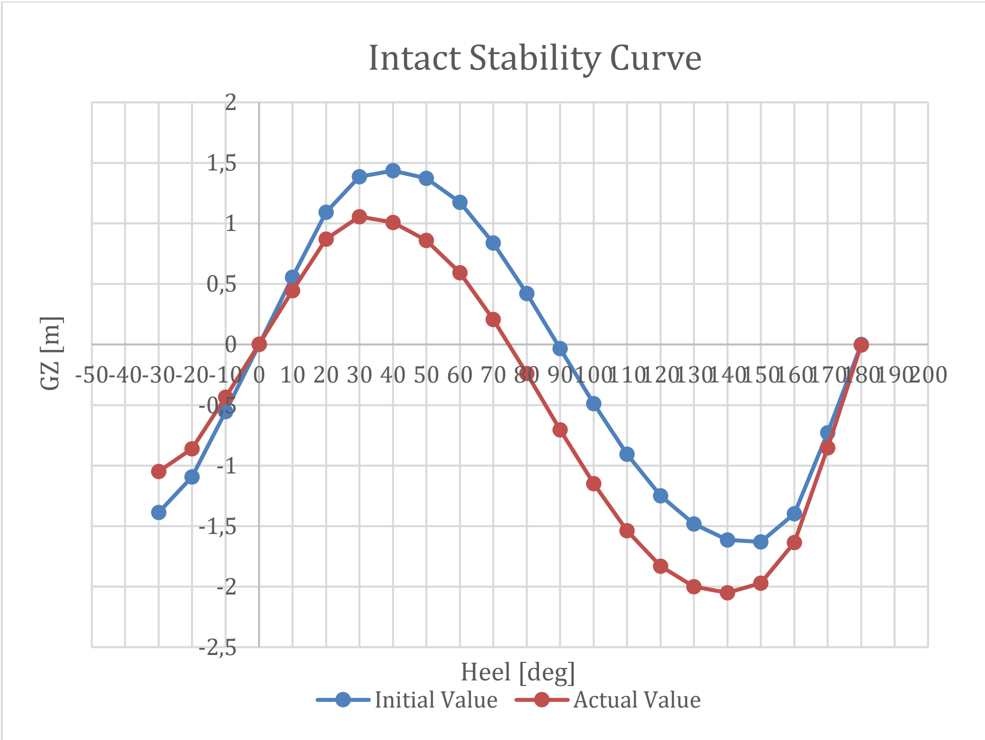
Stability calculation - Lines Maxsurf-191113 – 50% Load

Stability 21.11.00.84, build: 84
Model file: C:\Data_Maxsurf\ Lines Maxsurf-191113 (Highest precision, 200 sections, Trimming on, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - Loadcase 4
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m
Lightship	1	500,000	500,000			18,610	0,000	3,750	0,000
Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000
Truck 1	1	20,000	20,000			22,650	0,000	4,700	0,000
Truck 2	1	19,500	19,500			31,150	0,000	4,700	0,000
Truck 3	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 4	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 1	1	3,000	3,000			22,650	-2,970	4,700	0,000
Car 2	1	2,500	2,500			22,650	2,970	4,700	0,000
Car 3	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 4	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Passenger	60	0,100	6,000			5,700	0,000	5,600	0,000
T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	9,878	21,000	-1,750	0,392	0,000
T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	9,878	21,000	1,750	0,392	0,000
T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	13,171	16,800	-1,750	0,392	0,000
T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	13,171	16,800	1,750	0,392	0,000
T.A.T. (C)	100%	22,239	22,239	22,239	22,239	3,673	0,000	1,961	0,000
T.A.B. No.1 (PS)	1%	27,440	0,274	26,771	0,268	28,540	-1,682	0,004	35,157
T.A.B. No.1 (SB)	1%	27,440	0,274	26,771	0,268	28,540	1,682	0,004	35,157
T.A.B. No.2 (PS)	1%	21,442	0,214	20,919	0,209	4,570	-2,921	0,430	8,789
T.A.B. No.2 (SB)	1%	21,442	0,214	20,919	0,209	4,570	2,921	0,430	8,789
T.C.H.	1%	42,136	0,421	41,108	0,411	38,338	0,000	0,606	227,901
T.M.K.	1%	4,057	0,041	4,410	0,044	9,000	-0,875	0,004	1,479
T. Bilga	1%	4,410	0,044	4,410	0,044	9,000	0,875	0,004	1,608
Total Loadcase			614,645	214,585	69,790	18,510	-0,002	3,561	318,882
FS correction								0,519	
VCG fluid								4,080	





Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0
GZ m	-1,115	-0,957	-0,492	0,002	0,497	0,962	1,120	1,041
Area under GZ curve from zero heel m.deg	20,3939	9,8337	2,4200	0,0044	2,4718	9,9131	20,5889	31,5106
Displacement t	614,6	614,6	614,6	614,6	614,6	614,6	614,6	614,6
Draft at FP m	0,932	1,233	1,328	1,339	1,328	1,233	0,932	0,390
Draft at AP m	1,792	2,006	2,065	2,093	2,066	2,006	1,792	1,316
WL Length m	43,505	43,032	41,905	41,889	41,904	43,032	43,504	43,946
Beam max extents on WL m	9,340	10,712	10,662	10,500	10,662	10,712	9,341	8,658
Wetted Area m^2	459,984	489,971	496,444	501,151	496,444	489,966	459,986	449,519
Waterpl. Area m^2	345,805	390,414	404,850	408,601	404,849	390,408	345,805	327,684
Prismatic coeff. (Cp)	0,735	0,717	0,715	0,706	0,715	0,717	0,735	0,747
Block coeff. (Cb)	0,392	0,388	0,495	0,691	0,495	0,388	0,392	0,405
LCB from zero pt. (+ve fwd) m	18,447	18,450	18,456	18,453	18,455	18,449	18,445	18,447

Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0
LCF from zero pt. (+ve fwd) m	19,382	19,172	18,991	18,576	18,990	19,171	19,381	19,502
Max deck inclination deg	30,0159	20,0241	10,0496	1,0403	10,0497	20,0241	30,0160	40,0100
Trim angle (+ve by stern) deg	1,1860	1,0664	1,0175	1,0403	1,0184	1,0673	1,1876	1,2780

50,0	60,0	70,0	80,0	90,0	100,0	110,0	120,0	130,0	140,0	150,0	160,0
0,877	0,626	0,247	-0,198	-0,663	-1,109	-1,500	-1,793	-1,970	-2,050	-2,010	-1,720
41,1543	48,7677	53,2232	53,5011	49,1961	40,3054	27,1956	10,6337	-8,2702	-28,4553	-48,8758	-67,8924
614,6	614,6	614,6	614,6	614,6	614,7	614,6	614,6	614,6	614,6	614,6	614,6
-0,540	-2,258	-5,586	-15,200	n/a	-22,121	-12,514	-9,188	-7,476	-6,470	-5,853	-5,489
0,482	-0,828	-3,252	-10,224	n/a	-16,846	-9,870	-7,445	-6,173	-5,417	-4,973	-4,767
44,384	44,796	45,769	42,899	42,900	42,900	43,062	43,328	43,542	43,791	44,103	44,497
8,355	7,390	6,811	6,499	6,400	6,499	6,811	7,390	7,889	8,209	8,817	10,422
453,103	462,121	468,818	470,568	471,768	473,170	474,763	477,025	482,210	485,942	501,958	542,934
324,778	298,165	273,475	259,959	255,152	258,254	269,714	289,046	305,697	315,523	340,673	397,742
0,755	0,759	0,750	0,807	0,814	0,821	0,825	0,827	0,827	0,818	0,789	0,772
0,417	0,484	0,550	0,682	0,756	0,636	0,542	0,463	0,417	0,402	0,397	0,386
18,449	18,443	18,431	18,422	18,423	18,426	18,431	18,441	18,449	18,458	18,468	18,479
19,685	20,177	20,104	20,044	19,989	19,939	19,888	19,763	19,582	19,358	19,230	19,216
50,0060	60,0049	70,0039	80,0022	90,0000	99,9975	109,9951	119,9927	129,9902	139,9871	149,9833	159,9790
1,4102	1,9726	3,2186	6,8363	n/a	7,2440	3,6450	2,4046	1,7990	1,4538	1,2136	0,9958

170,0	180,0
-0,921	-0,002
-81,3922	-86,0070
614,6	614,6
-5,385	-5,392
-4,761	-4,758
46,420	45,732
10,662	10,500
594,052	595,839
455,712	448,734
0,743	0,752
0,476	0,752
18,485	18,485
20,113	20,106
169,9644	179,1248
0,8618	0,8752

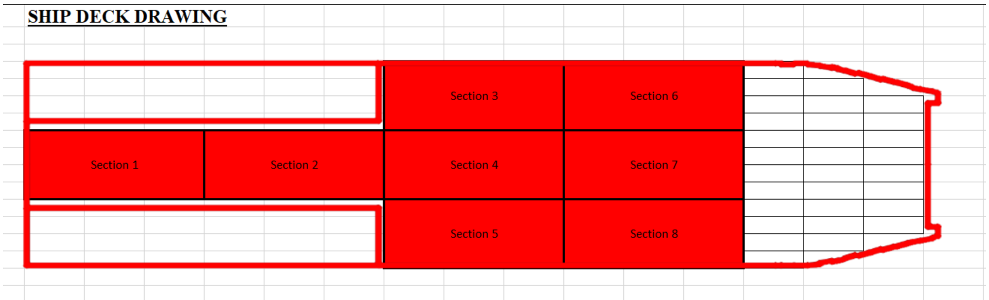
Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater	0,200	m	1,120	Pass	+460,00
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ	25,0	deg	30,0	Pass	+20,00
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt	0,150	m	2,855	Pass	+1803,33
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.5: Passenger crowding: angle of equilibrium	10,0	deg	0,1	Pass	+98,99
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.6: Turn: angle of equilibrium	10,0	deg	0,7	Pass	+93,44

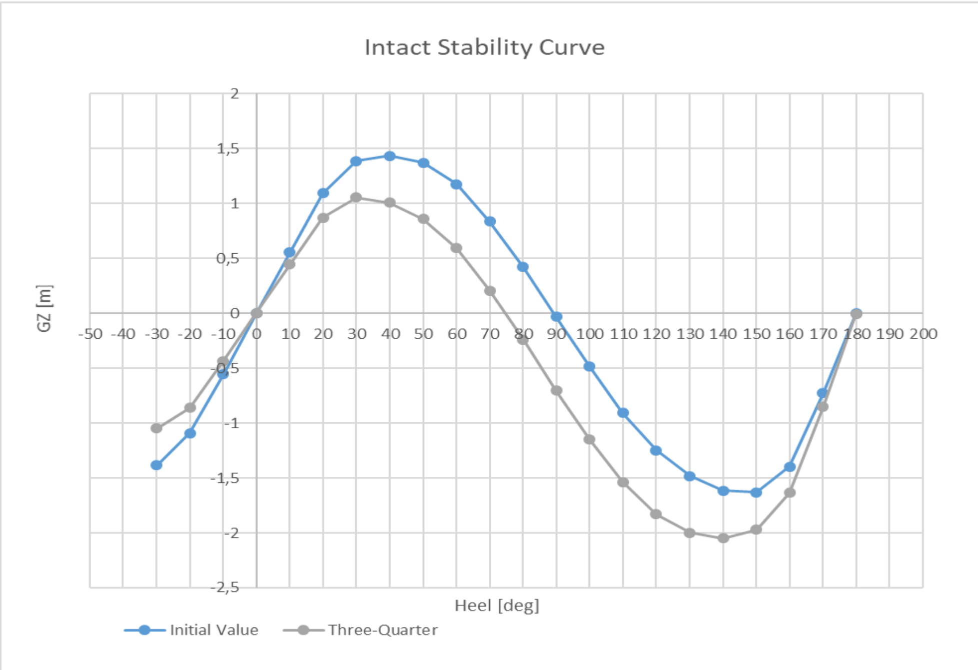
Stability calculation - Lines Maxsurf-191113 – 75% Load

Stability 21.11.00.84, build: 84
Model file: C:\Data_Maxsurf\ - Lines Maxsurf-191113 (Highest precision, 200 sections, Trimming on, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - Loadcase 4
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m
Lightship	1	500,000	500,000			18,610	0,000	3,750	0,000
Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000
Truck 1	1	20,000	20,000			31,150	0,000	4,700	0,000
Truck 2	1	21,000	21,000			22,650	0,000	4,700	0,000
Truck 3	1	20,500	20,500			4,450	0,000	4,470	0,000
Truck 4	1	20,000	20,000			14,150	0,000	4,700	0,000
Truck 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Truck 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 1	1	3,000	3,000			22,650	-2,970	4,700	0,000
Car 2	1	2,500	2,500			22,650	2,970	4,700	0,000
Car 3	1	3,000	3,000			31,150	-2,970	4,700	0,000
Car 4	1	2,500	2,500			31,150	2,970	4,700	0,000
Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Passenger	60	0,100	6,000			5,700	0,000	5,600	0,000
T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	9,878	21,000	-1,750	0,392	0,000
T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	9,878	21,000	1,750	0,392	0,000
T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	13,171	16,800	-1,750	0,392	0,000
T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	13,171	16,800	1,750	0,392	0,000
T.A.T. (C)	100%	22,239	22,239	22,239	22,239	3,673	0,000	1,961	0,000
T.A.B. No.1 (PS)	1%	27,440	0,274	26,771	0,268	28,540	-1,682	0,004	35,157
T.A.B. No.1 (SB)	1%	27,440	0,274	26,771	0,268	28,540	1,682	0,004	35,157
T.A.B. No.2 (PS)	1%	21,442	0,214	20,919	0,209	4,570	-2,921	0,430	8,789
T.A.B. No.2 (SB)	1%	21,442	0,214	20,919	0,209	4,570	2,921	0,430	8,789
T.C.H.	1%	42,136	0,421	41,108	0,411	38,338	0,000	0,606	227,901
T.M.K.	1%	4,057	0,041	4,410	0,044	9,000	-0,875	0,004	1,479
T. Bilga	1%	4,410	0,044	4,410	0,044	9,000	0,875	0,004	1,608
Total Loadcase			662,145	214,585	69,790	18,064	-0,004	3,636	318,882
FS correction								0,482	
VCG fluid								4,117	





Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0
GZ m	-1,048	-0,862	-0,436	0,004	0,445	0,870	1,056	1,007
Area under GZ curve from zero heel m.deg	18,4512	8,7435	2,1290	0,0082	2,2223	8,9026	18,7707	29,2173
Displacement t	662,1	662,2	662,1	662,1	662,1	662,1	662,2	662,1
Draft at FP m	0,896	1,198	1,298	1,320	1,298	1,199	0,896	0,350
Draft at AP m	2,106	2,266	2,303	2,313	2,303	2,266	2,107	1,691
WL Length m	43,469	43,002	41,882	41,877	41,882	43,003	43,468	43,899
Beam max extents on WL m	9,846	10,882	10,662	10,500	10,662	10,881	9,847	9,135
Wetted Area m^2	478,099	505,548	510,319	513,218	510,319	505,552	478,117	467,339
Waterpl. Area m^2	357,666	399,250	408,963	410,562	408,963	399,257	357,676	339,037
Prismatic coeff. (Cp)	0,712	0,696	0,701	0,696	0,701	0,696	0,711	0,723
Block coeff. (Cb)	0,379	0,389	0,499	0,681	0,499	0,389	0,379	0,390
LCB from zero pt. (+ve fwd) m	17,977	17,983	17,989	17,990	17,989	17,985	17,975	17,975
LCF from zero pt. (+ve fwd) m	19,105	18,981	18,797	18,492	18,797	18,983	19,103	19,215
Max deck inclination deg	30,0316	20,0460	10,0920	1,3717	10,0920	20,0459	30,0317	40,0209
Trim angle (+ve by stern) deg	1,6699	1,4741	1,3873	1,3717	1,3873	1,4726	1,6719	1,8509

50,0	60,0	70,0	80,0	90,0	100,0	110,0	120,0	130,0	140,0	150,0
0,861	0,594	0,207	-0,241	-0,705	-1,149	-1,539	-1,832	-2,000	-2,050	-1,972
38,6327	46,0162	50,0999	49,9616	45,2306	35,9285	22,4276	5,4783	-13,7828	-34,1270	-54,3714
662,1	662,1	662,1	662,1	662,1	662,2	662,1	662,1	662,1	662,2	662,2
-0,598	-2,348	-5,736	-15,508	n/a	-22,432	-12,659	-9,274	-7,525	-6,493	-5,863
0,955	-0,137	-2,149	-7,947	n/a	-14,563	-8,767	-6,753	-5,685	-5,042	-4,677
44,305	44,651	45,477	42,911	42,913	42,913	43,184	43,414	43,600	43,827	44,128
8,355	7,390	6,811	6,499	6,400	6,499	6,811	7,390	8,112	8,674	9,336
470,242	478,235	485,175	487,809	489,007	490,386	491,963	494,038	499,398	504,868	521,308
327,476	298,286	273,561	260,020	255,185	258,266	269,671	290,011	310,857	324,955	352,169
0,731	0,734	0,727	0,776	0,781	0,787	0,788	0,789	0,789	0,781	0,751
0,424	0,487	0,549	0,665	0,712	0,611	0,528	0,457	0,405	0,382	0,378
17,972	17,960	17,945	17,938	17,936	17,941	17,952	17,967	17,983	17,997	18,011
19,696	20,161	20,083	20,016	19,955	19,899	19,841	19,733	19,503	19,195	19,011
50,0139	60,0117	70,0091	80,0051	90,0000	99,9945	109,9893	119,9848	129,9805	139,9755	149,9696
2,1424	3,0500	4,9387	10,3240	n/a	10,7349	5,3568	3,4752	2,5388	2,0027	1,6372

160,0	170,0	180,0
-1,634	-0,854	-0,004
-72,7441	-85,4177	-89,6855
662,2	662,1	662,1
-5,493	-5,398	-5,405
-4,537	-4,548	-4,545
44,515	46,456	45,764
11,115	10,662	10,500
563,896	604,947	606,704
412,116	455,594	448,611
0,731	0,706	0,715
0,366	0,473	0,716
18,026	18,032	18,032
18,962	20,088	20,080
159,9631	169,9342	178,8139
1,3200	1,1727	1,1861

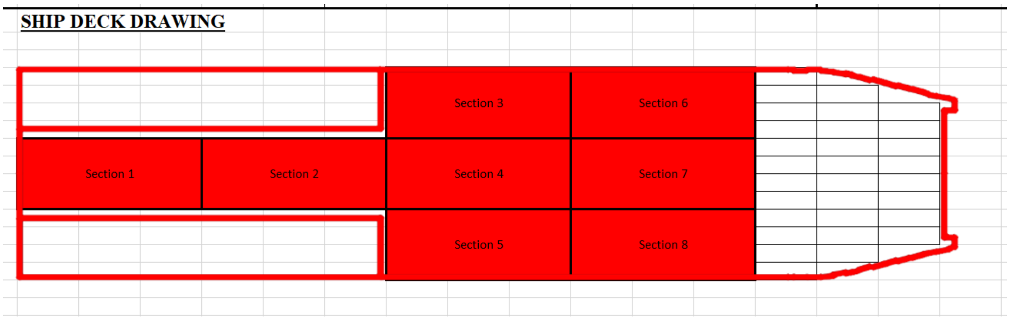
Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater	0,200	m	1,061	Pass	+430,50
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ	25,0	deg	31,8	Pass	+27,27
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt	0,150	m	2,532	Pass	+1588,00
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.5: Passenger crowding: angle of equilibrium	10,0	deg	0,1	Pass	+99,46
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.6: Turn: angle of equilibrium	10,0	deg	0,7	Pass	+93,03

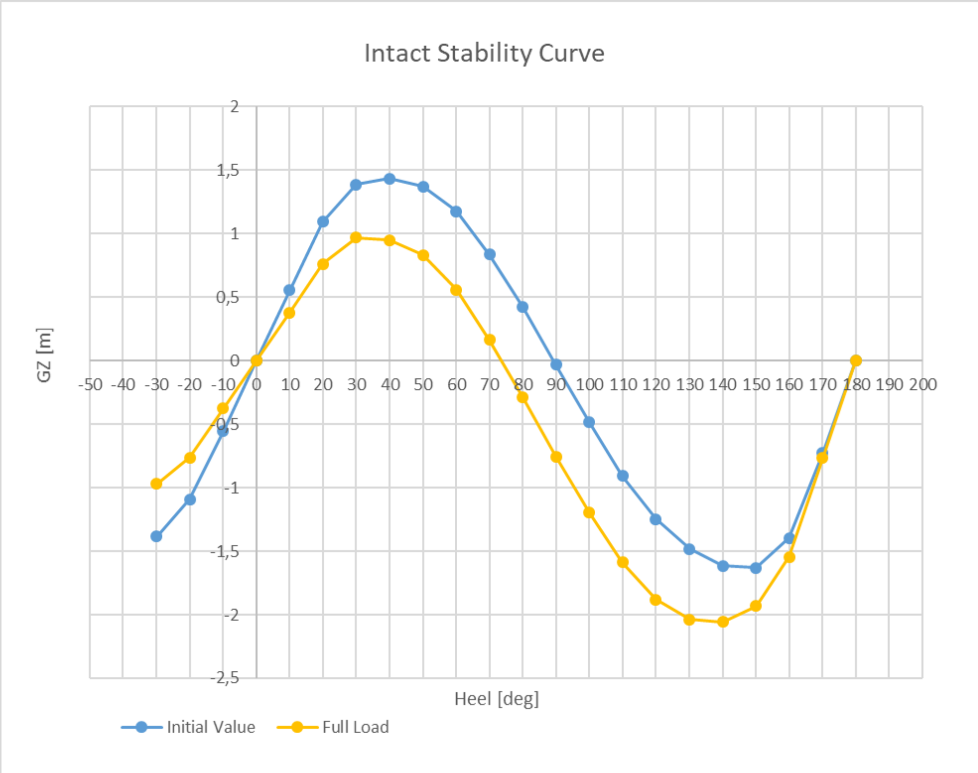
Stability calculation - Lines Maxsurf-191113 – 100% Load

Stability 21.11.00.84, build: 84
Model file: C:\Data_Maxsurf\ Lines Maxsurf-191113 (Highest precision, 200 sections, Trimming on, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - Loadcase 4
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
Lightship	1	500,000	500,000			18,610	0,000	3,750	0,000	User Specified
Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000	User Specified
Truck 1	1	20,000	20,000			4,450	0,000	4,700	0,000	User Specified
Truck 2	1	21,000	21,000			14,150	0,000	4,700	0,000	User Specified
Truck 3	1	19,000	19,000			22,650	-2,970	4,700	0,000	User Specified
Truck 4	1	20,500	20,500			22,650	0,000	4,700	0,000	User Specified
Truck 5	1	19,500	19,500			22,650	2,970	4,700	0,000	User Specified
Truck 6	1	20,000	20,000			31,150	-2,970	4,700	0,000	User Specified
Truck 7	1	21,500	21,500			31,150	0,000	4,700	0,000	User Specified
Truck 8	1	19,500	19,500			31,150	2,970	4,700	0,000	User Specified
Car 1	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 2	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 3	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 4	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000	User Specified
Passenger	112	0,000	0,000			5,700	0,000	5,600	0,000	User Specified
T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	9,878	21,000	-1,750	0,392	0,000	Maximum
T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	9,878	21,000	1,750	0,392	0,000	Maximum
T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	13,171	16,800	-1,750	0,392	0,000	Maximum
T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	13,171	16,800	1,750	0,392	0,000	Maximum
T.A.T. (C)	100%	22,239	22,239	22,239	22,239	3,673	0,000	1,961	0,000	Maximum
T.A.B. No.1 (PS)	1%	27,440	0,274	26,771	0,268	28,540	-1,682	0,004	35,157	Maximum
T.A.B. No.1 (SB)	1%	27,440	0,274	26,771	0,268	28,540	1,682	0,004	35,157	Maximum
T.A.B. No.2 (PS)	1%	21,442	0,214	20,919	0,209	4,570	-2,921	0,430	8,789	Maximum
T.A.B. No.2 (SB)	1%	21,442	0,214	20,919	0,209	4,570	2,921	0,430	8,789	Maximum
T.C.H.	1%	42,136	0,421	41,108	0,411	38,338	0,000	0,606	227,901	Maximum
T.M.K.	1%	4,057	0,041	4,410	0,044	9,000	-0,875	0,004	1,479	Maximum
T. Bilga	1%	4,410	0,044	4,410	0,044	9,000	0,875	0,004	1,608	Maximum
Total Loadcase			724,645	214,585	69,790	19,017	0,000	3,727	318,882	
FS correction								0,440		
VCG fluid								4,167		





Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0
GZ m	-0,970	-0,761	-0,377	0,000	0,377	0,761	0,970	0,948
Area under GZ curve from zero heel m.deg	16,3967	7,6242	1,8521	0,0000	1,8566	7,6055	16,4658	26,1838
Displacement t	724,6	724,6	724,6	724,6	724,6	724,6	724,6	724,6
Draft at FP m	1,410	1,641	1,720	1,742	1,721	1,641	1,410	0,942
Draft at AP m	2,017	2,179	2,221	2,234	2,221	2,179	2,016	1,595
WL Length m	43,986	43,428	42,518	42,283	42,518	43,428	43,987	44,532
Beam max extents on WL m	9,874	10,893	10,662	10,500	10,662	10,893	9,873	9,160
Wetted Area m^2	502,940	527,209	529,682	531,890	529,683	527,209	502,942	493,704
Waterpl. Area m^2	375,138	413,772	418,093	419,073	418,093	413,773	375,140	356,874
Prismatic coeff. (Cp)	0,766	0,753	0,753	0,752	0,753	0,753	0,766	0,775
Block coeff. (Cb)	0,407	0,420	0,536	0,739	0,536	0,420	0,407	0,418
LCB from zero pt. (+ve fwd) m	18,972	18,977	18,980	18,981	18,980	18,978	18,973	18,974
LCF from zero pt. (+ve fwd) m	19,681	19,559	19,346	18,958	19,347	19,559	19,682	19,857
Max deck inclination deg	30,0080	20,0117	10,0229	0,6800	10,0229	20,0117	30,0079	40,0050
Trim angle (+ve by stern) deg	0,8380	0,7432	0,6904	0,6800	0,6904	0,7427	0,8371	0,9010

50,0	60,0	70,0	80,0	90,0	100,0	110,0	120,0	130,0	140,0	150,0
0,833	0,559	0,163	-0,289	-0,754	-1,198	-1,587	-1,882	-2,039	-2,057	-1,934
35,1823	42,2786	45,9609	45,3573	40,1365	30,3434	16,3591	-1,0819	-20,8060	-41,3933	-61,4862
724,6	724,6	724,6	724,6	724,6	724,7	724,6	724,6	724,6	724,6	724,6
0,103	-1,357	-4,134	-12,159	n/a	-19,032	-11,005	-8,223	-6,768	-5,897	-5,379
0,848	-0,283	-2,399	-8,481	n/a	-15,114	-9,034	-6,921	-5,800	-5,122	-4,735
45,110	45,914	42,894	42,895	42,896	42,896	42,896	42,895	42,961	43,298	43,680
8,355	7,390	6,811	6,499	6,400	6,499	6,811	7,390	8,137	8,686	9,305
499,549	505,998	507,314	508,278	509,409	510,748	512,315	514,360	519,840	528,080	545,630
340,784	299,707	274,718	261,066	256,198	259,291	270,828	292,784	319,346	340,962	369,811
0,780	0,775	0,837	0,844	0,851	0,857	0,865	0,873	0,879	0,874	0,855
0,452	0,514	0,632	0,726	0,808	0,690	0,597	0,518	0,457	0,430	0,426
18,975	18,968	18,961	18,957	18,956	18,958	18,962	18,969	18,976	18,983	18,990
20,350	20,259	20,179	20,119	20,066	20,018	19,972	19,928	19,819	19,697	19,556
50,0032	60,0028	70,0021	80,0012	90,0000	99,9986	109,9972	119,9959	129,9946	139,9930	149,9911
1,0287	1,4826	2,3944	5,0653	n/a	5,3925	2,7188	1,7977	1,3370	1,0688	0,8884

160,0	170,0	180,0
-1,546	-0,767	0,000
-79,2160	-90,9535	-94,7217
724,6	724,7	724,6
-5,115	-5,090	-5,096
-4,579	-4,575	-4,572
44,153	46,122	45,443
10,957	10,662	10,500
590,519	619,800	621,773
432,452	455,125	448,156
0,830	0,794	0,804
0,415	0,528	0,804
18,997	18,999	18,999
19,505	20,106	20,100
159,9884	169,9758	179,2766
0,7406	0,7102	0,7234

Key point	Type	Immersion angle deg	Emergence angle deg
Margin Line (immersion pos = -1,191 m)		43,1	n/a
Deck Edge (immersion pos = -1,191 m)		43,8	n/a

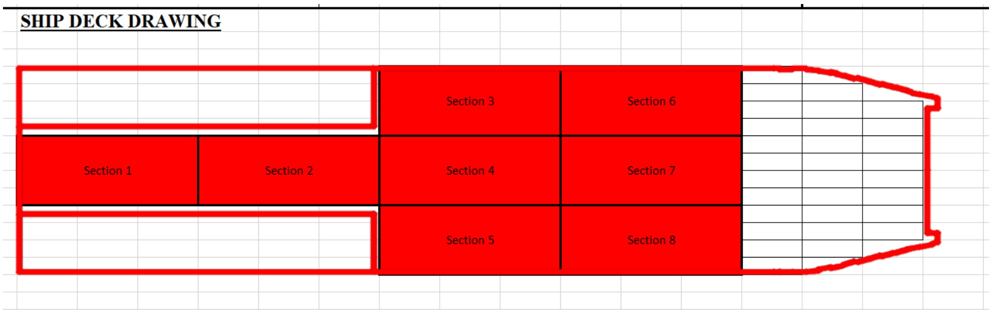
Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater	0,200	m	0,981	Pass	+390,50
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ	25,0	deg	32,7	Pass	+30,91
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt	0,150	m	2,160	Pass	+1340,00
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.5: Passenger crowding: angle of equilibrium	10,0	deg	0,2	Pass	+98,30
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.6: Turn: angle of equilibrium	10,0	deg	0,9	Pass	+90,64

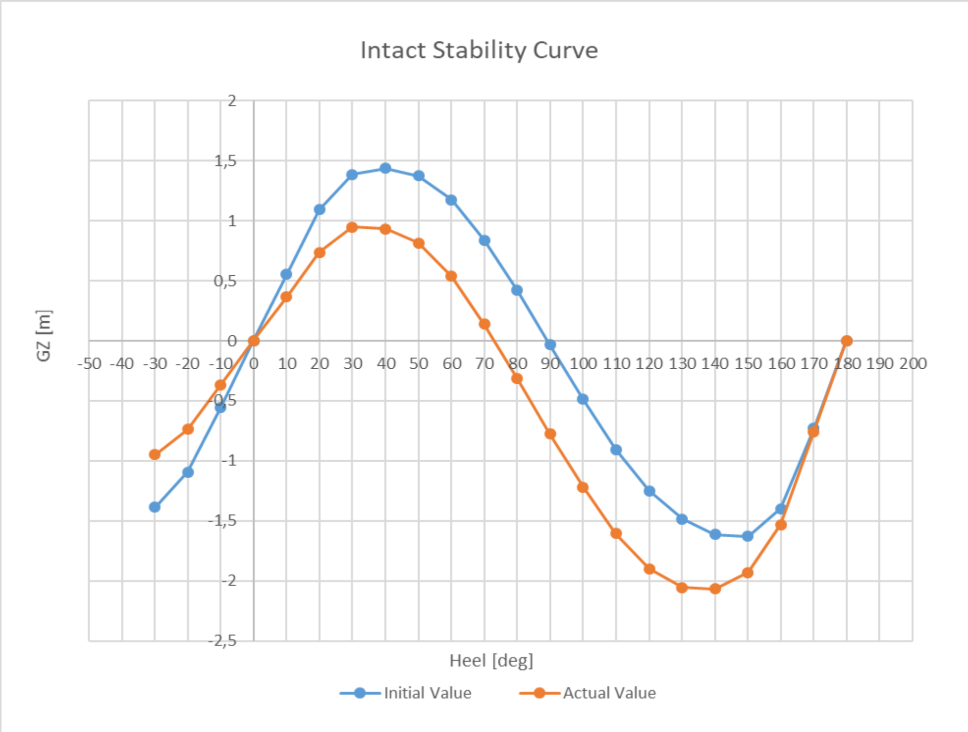
Stability calculation - Lines Maxsurf-191113 – 125% Load

Stability 21.11.00.84, build: 84
Model file: C:\Data_Maxsurf\ - Lines Maxsurf-191113 (Highest precision, 200 sections, Trimming on, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - Loadcase 4
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m
Lightship	1	500,000	500,000			18,610	0,000	3,750	0,000
Crew & Effect (@100 kg)	12	0,100	1,200			13,800	0,000	8,000	0,000
Truck 1	1	26,000	26,000			4,450	0,000	4,700	0,000
Truck 2	1	25,000	25,000			14,150	0,000	4,700	0,000
Truck 3	1	25,000	25,000			22,650	-2,970	4,700	0,000
Truck 4	1	25,500	25,500			22,650	0,000	4,700	0,000
Truck 5	1	25,500	25,500			22,650	2,970	4,700	0,000
Truck 6	1	25,000	25,000			31,150	-2,970	4,700	0,000
Truck 7	1	25,000	25,000			31,150	0,000	4,700	0,000
Truck 8	1	24,500	24,500			31,150	2,970	4,700	0,000
Car 1	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 2	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 3	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 4	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 5	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 6	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 7	0	0,000	0,000			0,000	0,000	0,000	0,000
Car 8	0	0,000	0,000			0,000	0,000	0,000	0,000
Passenger	112	0,000	0,000			5,700	0,000	5,600	0,000
T.B.B. No.1 (PS)	98%	8,467	8,298	10,079	9,878	21,000	-1,750	0,392	0,000
T.B.B. No.1 (SB)	98%	8,467	8,298	10,079	9,878	21,000	1,750	0,392	0,000
T.B.B. No.2 (PS)	98%	11,289	11,064	13,439	13,171	16,800	-1,750	0,392	0,000
T.B.B. No.2 (SB)	98%	11,289	11,064	13,439	13,171	16,800	1,750	0,392	0,000
T.A.T. (C)	100%	22,239	22,239	22,239	22,239	3,673	0,000	1,961	0,000
T.A.B. No.1 (PS)	1%	27,440	0,274	26,771	0,268	28,540	-1,682	0,004	35,157
T.A.B. No.1 (SB)	1%	27,440	0,274	26,771	0,268	28,540	1,682	0,004	35,157
T.A.B. No.2 (PS)	1%	21,442	0,214	20,919	0,209	4,570	-2,921	0,430	8,789
T.A.B. No.2 (SB)	1%	21,442	0,214	20,919	0,209	4,570	2,921	0,430	8,789
T.C.H.	1%	42,136	0,421	41,108	0,411	38,338	0,000	0,606	227,901
T.M.K.	1%	4,057	0,041	4,410	0,044	9,000	-0,875	0,004	1,479
T. Bilga	1%	4,410	0,044	4,410	0,044	9,000	0,875	0,004	1,608
Total Loadcase			765,145	214,585	69,790	19,172	0,000	3,778	318,882
FS correction								0,417	
VCG fluid								4,195	





Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0
GZ m	-0,920	-0,699	-0,343	0,000	0,343	0,699	0,920	0,919
Area under GZ curve from zero heel m.deg	15,1397	6,9530	1,6855	0,0000	1,6900	6,9342	15,2094	24,5362
Displacement t	765,1	765,1	765,1	765,1	765,1	765,1	765,1	765,1
Draft at FP m	1,575	1,783	1,857	1,882	1,857	1,783	1,575	1,130
Draft at AP m	2,096	2,243	2,280	2,289	2,280	2,243	2,096	1,696
WL Length m	44,155	43,568	42,978	42,413	42,978	43,568	44,155	44,733
Beam max extents on WL m	10,062	10,958	10,662	10,500	10,662	10,958	10,062	9,339
Wetted Area m^2	517,720	538,558	541,746	543,334	541,745	538,558	517,733	508,983
Waterpl. Area m^2	385,006	419,706	422,682	423,022	422,682	419,706	385,014	366,587
Prismatic coeff. (Cp)	0,776	0,765	0,761	0,767	0,761	0,765	0,776	0,783
Block coeff. (Cb)	0,412	0,430	0,546	0,754	0,546	0,430	0,412	0,422
LCB from zero pt. (+ve fwd) m	19,136	19,139	19,141	19,142	19,141	19,139	19,135	19,132
LCF from zero pt. (+ve fwd) m	19,756	19,632	19,471	19,105	19,471	19,632	19,756	19,941
Max deck inclination deg	30,0059	20,0085	10,0163	0,5607	10,0163	20,0085	30,0059	40,0037
Trim angle (+ve by stern) deg	0,7190	0,6353	0,5827	0,5607	0,5827	0,6350	0,7194	0,7808

50,0	60,0	70,0	80,0	90,0	100,0	110,0	120,0	130,0	140,0	150,0
0,812	0,529	0,130	-0,321	-0,784	-1,225	-1,610	-1,903	-2,057	-2,057	-1,906
33,2979	40,1456	43,5076	42,5764	37,0421	26,9656	12,7321	-4,9336	-24,8615	-45,5481	-65,5188
765,1	765,1	765,1	765,1	765,1	765,2	765,1	765,1	765,1	765,1	765,1
0,326	-1,025	-3,596	-11,035	n/a	-17,886	-10,445	-7,868	-6,514	-5,697	-5,215
0,986	-0,086	-2,090	-7,849	n/a	-14,489	-8,732	-6,731	-5,667	-5,018	-4,651
45,364	46,333	42,893	42,894	42,894	42,894	42,894	42,894	42,894	43,128	43,536
8,355	7,390	6,811	6,499	6,400	6,499	6,811	7,390	8,226	8,855	9,478
515,798	520,693	521,217	522,121	523,220	524,534	526,088	528,109	532,894	542,705	560,757
341,874	300,356	275,216	261,495	256,596	259,681	271,225	293,207	322,965	349,087	379,910
0,786	0,779	0,849	0,856	0,862	0,869	0,876	0,884	0,892	0,891	0,877
0,463	0,524	0,647	0,740	0,825	0,708	0,615	0,536	0,469	0,440	0,436
19,135	19,129	19,124	19,121	19,120	19,122	19,126	19,131	19,138	19,144	19,150
20,412	20,295	20,209	20,147	20,094	20,047	20,001	19,957	19,858	19,775	19,657
50,0025	60,0021	70,0016	80,0009	90,0000	99,9990	109,9979	119,9969	129,9959	139,9946	149,9931
0,9113	1,2961	2,0790	4,3899	n/a	4,6789	2,3637	1,5690	1,1693	0,9371	0,7789

160,0	170,0	180,0
-1,485	-0,724	0,000
-82,7831	-93,9607	-97,5078
765,1	765,1	765,1
-4,986	-4,979	-4,986
-4,512	-4,508	-4,505
44,035	46,011	45,335
11,146	10,662	10,500
607,042	629,224	631,212
444,512	454,902	447,938
0,849	0,811	0,822
0,425	0,546	0,822
19,155	19,156	19,156
19,593	20,103	20,097
159,9909	169,9797	179,3368
0,6541	0,6502	0,6632

Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater	0,200	m	0,940	Pass	+370,00
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ	25,0	deg	34,5	Pass	+38,18
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt	0,150	m	1,961	Pass	+1207,33
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.5: Passenger crowding: angle of equilibrium	10,0	deg	0,2	Pass	+98,23
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.6: Turn: angle of equilibrium	10,0	deg	1,0	Pass	+89,74

BIOGRAPHY OF WRITER

Arie Nanda Rizaldi is a bachelor candidate at Institut Teknologi Sepuluh Nopember where he is majoring in Marine Engineering with a focus in marine manufacturing and design field. His interest in marine manufacturing and design began during the odd semester of 2017 when he became the staff of marine manufacturing and design laboratory. He learned about various design software such as Maxsurf and AutoCad and became the tutor for other student to using AutoCad for college use. Beside of the activities for the laboratory, he is also active in several non-academic activities one of them is being the as deputy head of student resources development department in 2017, where he got non-academic experience about student resource development. When in that position he making several soft skill trainings for college student, also doing an review on the student resource development guideline. When he is not busy on campus activities, he enjoys reading book about general insight and self-development. He is also like to learn about computer stuff like coding and graphic design, also he like playing some video gamesi.